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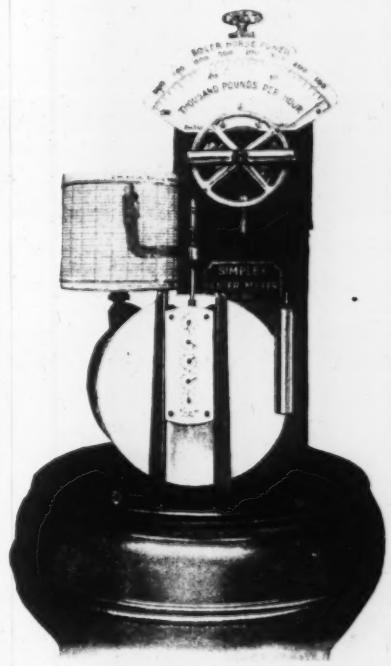

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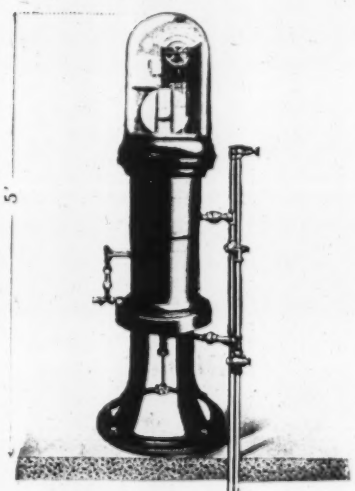

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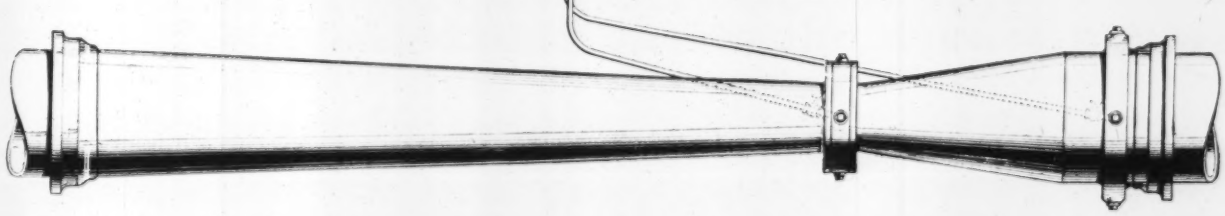

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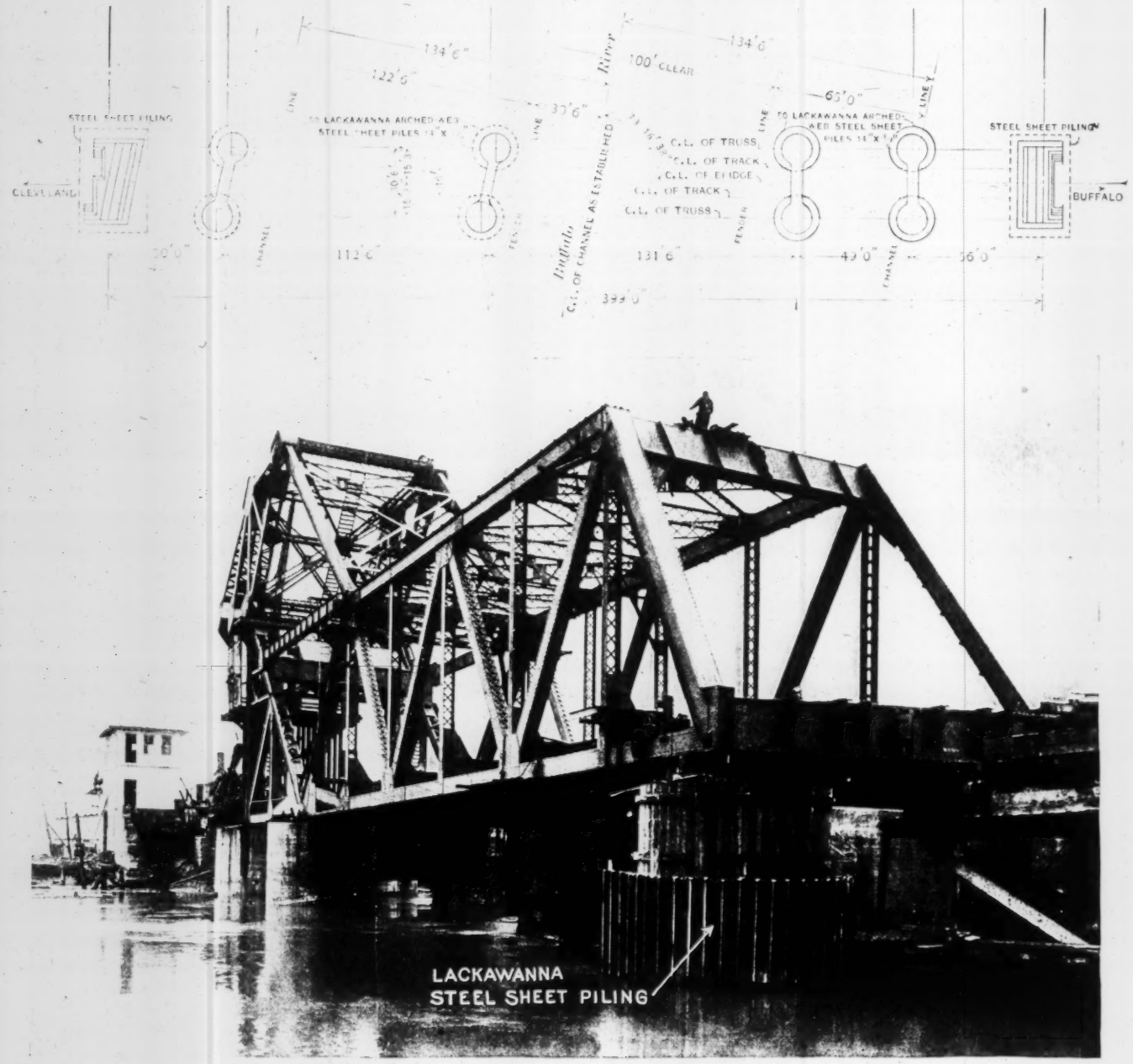

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Engineering News

CHARLES WHITING BAKER, *Editor*

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What The Buyer Needs To Know

Number Twenty-Five

A very curious case came to our attention the other day. It was so unusual that we believe you, too, will be greatly interested in it.

A few years ago *Rubifoam* was a national tooth wash. Our sisters, our cousins and our aunts used it. It was sold practically all over the country. And the girl with the *Rubifoam* smile was as well known as—well, say as well known as a Vice-Presidential nominee before his election.

But suddenly this girl disappeared. Her dazzling smile no longer lighted up magazine pages, glorified billboards, burst forth from newspapers. *Rubifoam* was no longer advertised.

A coterie of advertising men got together and decided to go after the manufacturer of *Rubifoam* and find out the why and wherefore of Miss Rubifoam's retirement.

This manufacturer lived up in New England.

"What's the matter—lost your nerve; didn't the advertising pay you?" asked the advertising men when at last they confronted the manufacturer.

He shook his head, smiled. "Yes, it paid me. I believe in it—thoroughly."

Naturally his questioners were dumbfounded. "Well, what—!"

"You see, gentlemen, it's this way. I've built up this business entirely by myself. I have no one to whom to leave it. I have no idea how it would be managed after my death—no idea as to whether the standard of the product would be kept up. I want to guard against its deterioration. So I've simply let the advertising drop and the business is slowly dying. I figure by the time I'm ready to pass in my checks the business will be about finished, too."

The advertising men, when they had sufficiently recovered from their astonishment, told him it was his duty to the community to continue advertising, that he was throwing his employees out of work and tried a host of similar arguments. But the manufacturer refused to give up his peculiar views regarding the matter.

It would cause an earthquake like a hundred panics combined if all advertisers should suddenly make a decision similar to this which the manufacturer of *Rubifoam* made.

Imagine the quandary you'd be in. Where would you buy the things that are absolutely essential to you?

There was a time when man was almost entirely independent of other men.

He tilled his own ground (or rather his wife did), raised the vegetables and fruits he needed and killed the meat and clothed himself with the skins of the animals he killed.

But year after year, century after century, that kind of independence has slowly gone. Modern man is dependent upon his fellow men.

Like a huge net this dependence of ours upon each other stretches through the fabric of life.

Today we look to others for the bed we lie in, the house we live in, the clothes we wear, even the food we eat. Others look to us for that one small thing which is our product.

New York City, shut off from its food supplies, would have a starving population within 48 hours.

Advertising is the means by which men offer their product to as many other men as possible—hundreds of men, thousands of men where before they could only reach individuals.

Advertising enables men who manufacture the machinery you use to come direct to you with their product no matter where you are.

The advertisers, of course, depend upon you but you also depend upon the advertisers.

Think about it as you read over the Selling Section this week.

Engineering News

VOLUME 69 JUNE 19, 1913 NUMBER 25

The Completion of the Los Angeles Aqueduct

By Burt A. Heinly*

Next November the City of Los Angeles expects to formally dedicate to public use its new water-works system by which the municipality is to draw upon the streams of the Sierra Nevada Mountains, 250 miles distant, for a supplementary domestic supply. The occasion will be one of more than ordinary note for doubtless no ancient or modern city of its size has undertaken and carried to successful completion a project of such monumental magnitude. Likewise, also, no American city has such possibilities of economic and financial returns to its citizens from a municipal enterprise as has Los Angeles in the Los Angeles Aqueduct if its affairs are managed with judgment and business acumen. The dedicatory exercises with the several days of attendant celebration, aside from the completion of the enterprise, are to be made worthy of note by the attendance of various government officials and of the governors of many of the Western States together with their staffs.

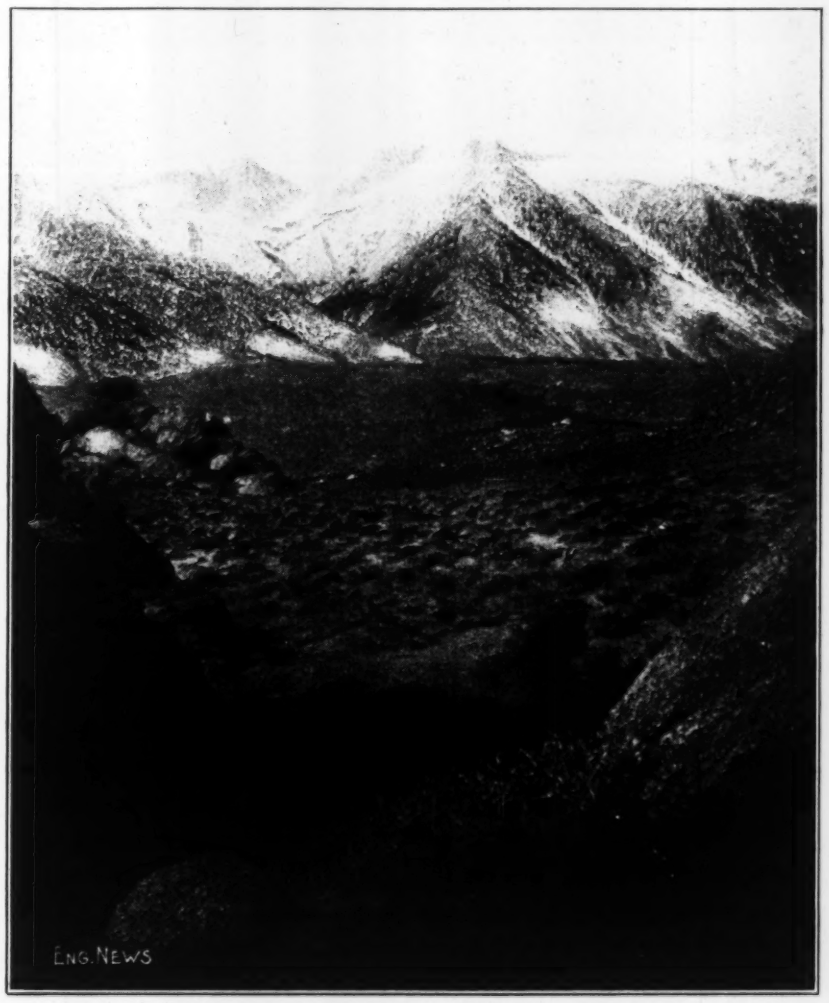


Fig. 1. The Headwaters of the Los Angeles Aqueduct

(A part of the main range of the Sierras. Mt. Whitney, Elev. 14,502, the highest peak in the United States, appears in the background, near the extreme left.)

Because of the articles that have appeared in this and other publications on various phases of the undertaking and in view of the fact that other articles will appear from time to time on the same subject now that the Aqueduct, *per se*, is completed, the writer believes that a brief description of the works with some reference to the historical details and a concrete explanation of the plans of operation and the future economic importance of the task will be of more than common interest to the engineering profession.

Any general description of the work, however brief, must take up the three following phases—all of them unusual and each, depending upon the viewpoint of the reader, of first importance:

(1) The project stands as one of the most extensive water-works systems in existence, built under most adverse conditions of climate and topography.

(1) With the exception of 9 miles of construction, the commissary department and the hospital and medical divisions, which were under contract, the enterprise has been accomplished under the direct control and supervision of the city. The undertaking has been completed in larger detail and at something under the $24,500,000 voted for the purpose and the time of estimated construction has not been exceeded. To advocates of municipal construction of public works an interesting field of investigation is here opened.

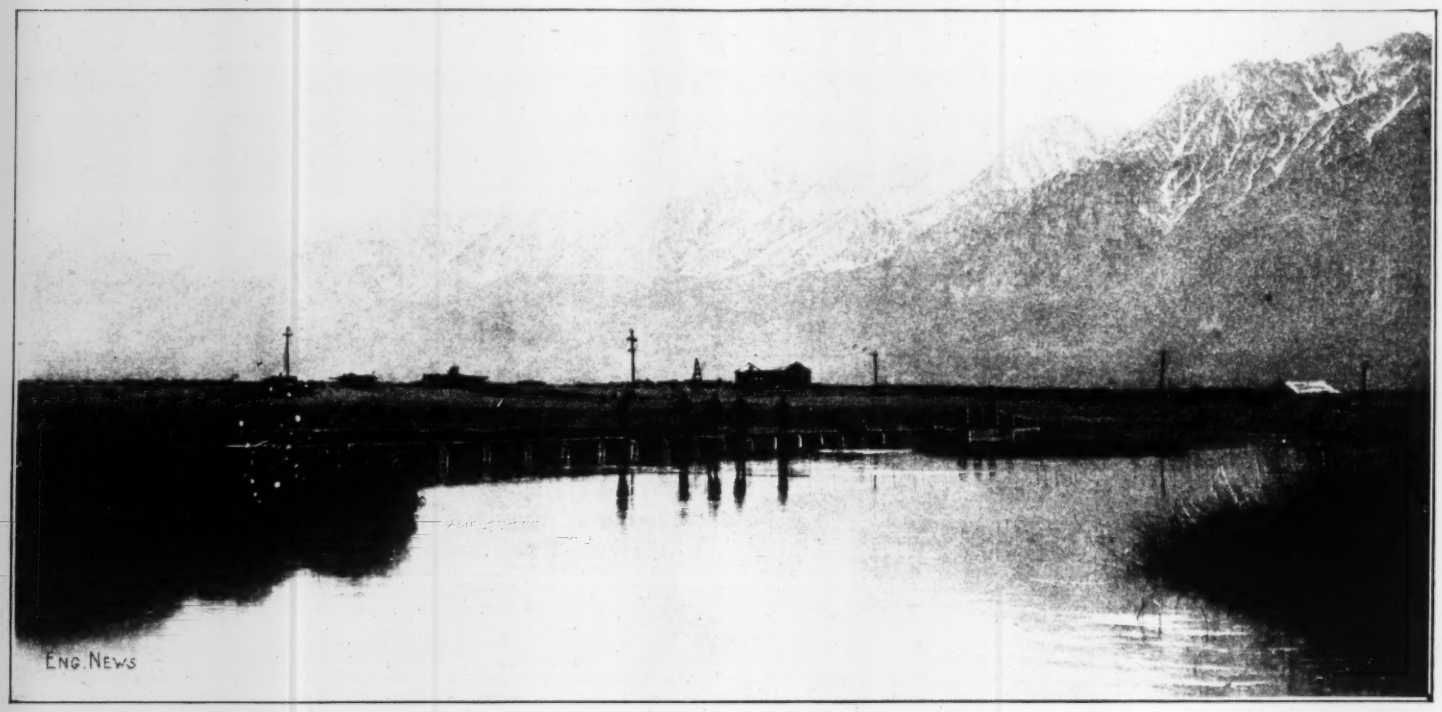
(3) While primarily a water-works system, the Los Angeles Aqueduct provides for the irrigation for a long term of years of 135,000 acres of land with surplus water and for the development of a maximum of 120,000 hp. of electrical energy, so that to the municipal economist this phase of the undertaking would stand first.

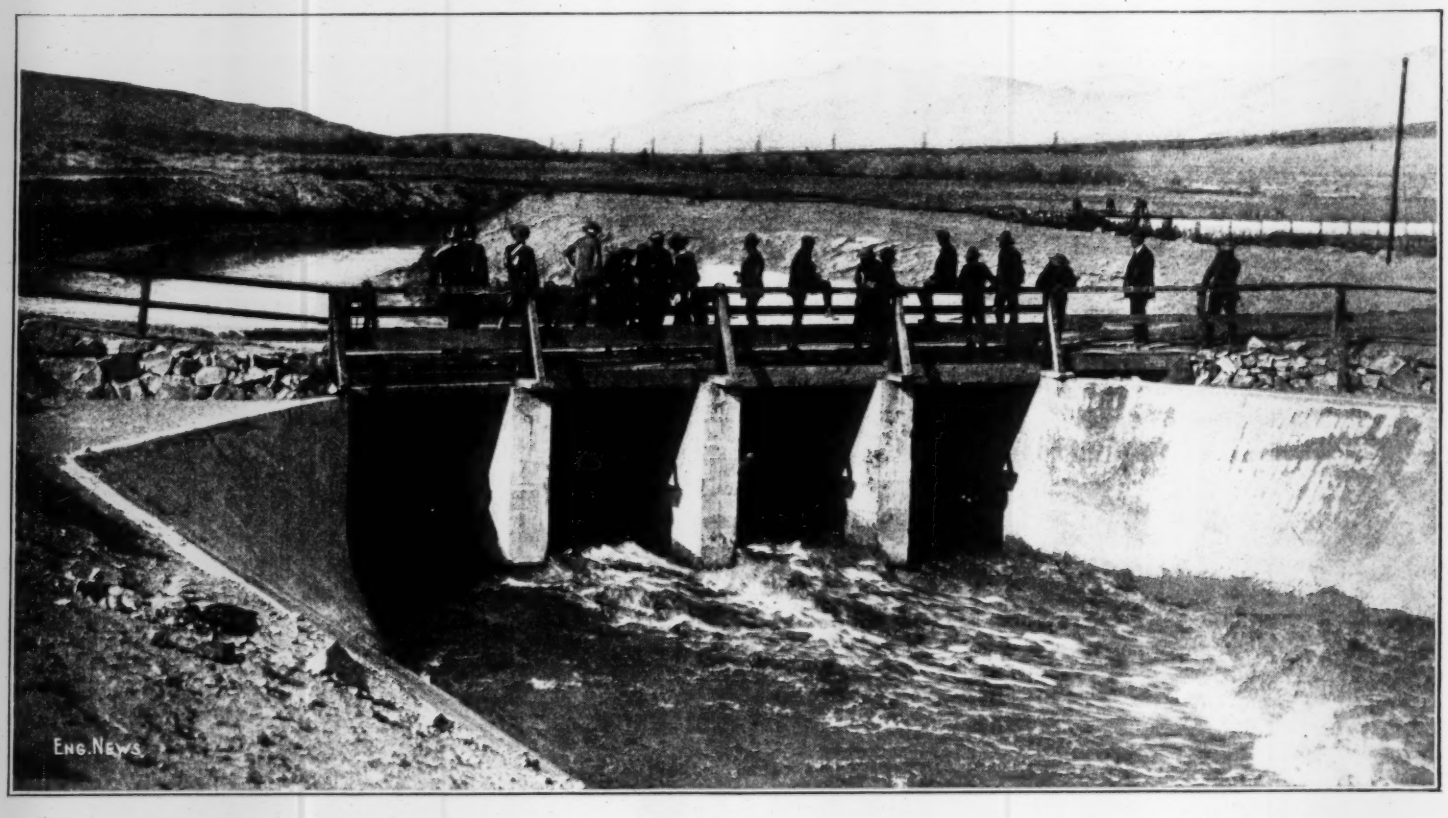
Before entering upon an outline description of the engineering work, the writer desires to present certain facts that are not apparently well understood even in his own city.

The Aqueduct, *per se*, has a total length of 234.7 miles, but the outlet of the Aqueduct is 24 miles northwest of

*City Water Department, 636 South Hill St., Los Angeles, Calif.

the city. To procure the Sierra supply it is necessary for Los Angeles to carry the water from the outlet of the Aqueduct across the San Fernando Valley by 13 miles of 72- to 62-in. steel inverted siphon, through the crest of the Santa Monica Mountains by a tunnel 3781 ft. long, down Franklin Cañon and take it into the distributing mains on the western edge of the city. While the Aqueduct is all but completed and is to be formally dedicated, it is hardly possible that Los Angeles can draw upon the new supply before the summer of 1914 as the construction of the trunk line is just now being undertaken. The explanation of the division of the work is two-fold: What was of vital importance in 1907 when construction was undertaken was that the total bond issue of $24,500,000 exhausted the limit of the city's legal indebtedness. Moreover, geographically, the Aqueduct ends in the two reservoir sites on the rim of the San Fernando Valley and it was decided that the districts desiring surplus water for irrigation should build their pipe lines at their own expense and that the city should build its supply main out of the general revenues of its Water Department. This, as well as the fact that approxi-





FIGS. 2 AND 3. WIER AND HEADGATES, OWENS RIVER DIVERSION TO LOS ANGELES AQUEDUCT

(In the lower view the headgates were being opened on Feb. 9, 1913, when the first 60 miles of the Aqueduct and the Haiwee Reservoir were placed in operation.)

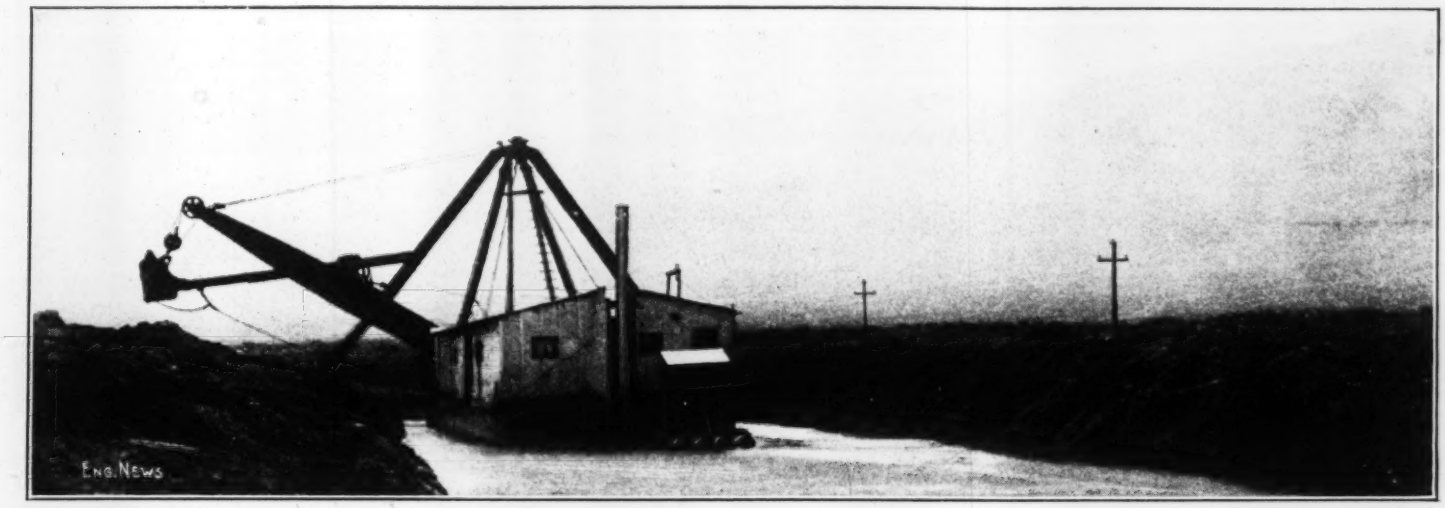


FIG. 4. DIPPER DREDGE EXCAVATING CANAL SECTION IN OWENS VALLEY, LOS ANGELES AQUEDUCT

mately 10 miles are classed as power construction, will explain the many discrepancies as to the length of the system.

Again: The Owens River supply is supplementary to that of the present one, amounting to 40,000,000 gal. per day from the Los Angeles River. The water from present sources is pure and good and there is no reason why in a country where water for all purposes is at such a premium that the city should in any way surrender its riparian rights in the stream which date back to the founding of the pueblo in 1781. Also, there will be no changes of moment in either the present pumpage or gravity distribution systems. The only improvements needed are those which have already been accomplished during the past five years. These consist mainly, as they apply to the new source, of laying extra large mains toward the sea in the southwest part of the city where the growth of population is most rapid, and extending large-size connecting mains at right angles and across the city to the eastward.

The Los Angeles Aqueduct, or the Owens River project as it is often popularly denominated, was conceived in 1904 and came as a result of the dwindling sources of the city's supply from the surface and sub-flow of the Los Angeles River. The Owens River, with its tributary streams draining the eastern face of the Sierra Nevada Range (the roofshed of the United States) for a distance of 120 miles, was found to be the only available source of adequate supply. In the valley of this stream, the city's Board of Water Commissioners, out of the funds of the Water Department, secretly began in the early part of 1905 to take options on lands and appurtenant water rights. July 1, 1905, these negotiations had reached a point where speculators could not impose upon the municipality and the plans of the board with a report on the negotiations in the valley were made public. In September of the same year, the people voted $1,500,000 to take up the options and carry on the preliminary engineering investigations. By the fall of 1906, the plans and estimates had been completed under the direction of William Mulholland, the city's Water Superintendent, and his chief assistant, J. B. Lippincott. In December of that year, after several months of study and field inspection, a consulting board of engineers composed of Messrs. John R. Freeman, Frederick P. Stearns and James D. Schuyler (now dead) gave the project their approval practically as it was outlined. In June of 1907 the people voted $23,000,000, the amount of Mr. Mulholland's estimate, to undertake the work, it being understood that power development must be made from future bond issues for that purpose.

A classification of the work as it has been carried out, includes the construction noted in the table at the top of the next column.

FIG. 5. CAMP IN THE SANTA SUSANA RANGE

FIG. 6. CAMP ON THE JAWBONE DIVISION

(These views give some idea of the mountainous country through which much of the Los Angeles Aqueduct was built. Of 23 miles in the Jawbone division, 20.5 miles were tunnel construction.)

Classification	Length in miles
Tunnel	42 69
Power tunnel	9 23
Open unlined canal	21 14
Open lined canal	39 56
Concrete-covered conduit	97 72
Haiwee by-pass	1 95
Siphons (steel and concrete)	12 06
Flumes	0 17
Power penstock	0 44
Other power construction	0 30
Reservoirs	8 50
Total length of aqueduct	233 76

Of the foregoing, 51,000 ft., exclusive of penstocks, is classed as power construction with a *pro rata* of cost defrayed from the power bonds issue of $3,500,000 for the reason that it was necessary to adapt the designs of the Aqueduct to meet the needs of power development. This is particularly true of a stretch of seven miles leading from the outlet of the Elizabeth tunnel (17 miles from Los Angeles). At this point, the original design of the Aqueduct as a water-works provided for the use of the natural channel of the San Francisquito Cañon for a distance of 7 miles, the water being caught up at the cañon's outlet, thence carried by means of tunnels, siphons and small stretches of conduit through the heart of the Santa Susana Mountain range and into the San Fernando reservoirs at the Aqueduct outlet. The change to meet power requirements makes it necessary to carry the Aqueduct along the rim of the cañon. As money from the sale of power bonds was not available until 1911, work on the power section was not undertaken until July of that year. About 1000 ft. of tunnel with some tunnel lining still remains to be accomplished on this stretch and temporarily, at least, the floor of the cañon must be used. This will in no way affect the operation of the Aqueduct as a water-works project.

The intake of the system at an elevation of 3812 ft. above sea level, is situated 11 miles north of the town of Independence, Inyo County, Calif., where the whole normal flow of the Owens River is diverted into an unlined canal of a capacity of 800 sec.-ft. This canal, 21.14 miles in length, is unlined for the reason that a considerable quantity of the underground flow of the valley is taken up. At the northern toe of the Alabama Foot Hills, not far from the mouth of the Valley, the Aqueduct assumes the form of an open concrete-lined ditch, 39.56 miles in length and with a capacity of 900 sec.-ft. This ditch empties into the Haiwee Reservoir and is of a capacity of more than double that of the rated delivery of the Aqueduct in order to take care of the flood flow of the Owens River and tributary streams which it is the duty of the Haiwee Reservoir to impound, clarify and sterilize. This basin, with a capacity of 63,800 acre-feet, acts as the balance for the whole system. This first part of the system was placed in operation Feb. 9, 1913, with the most satisfactory results.

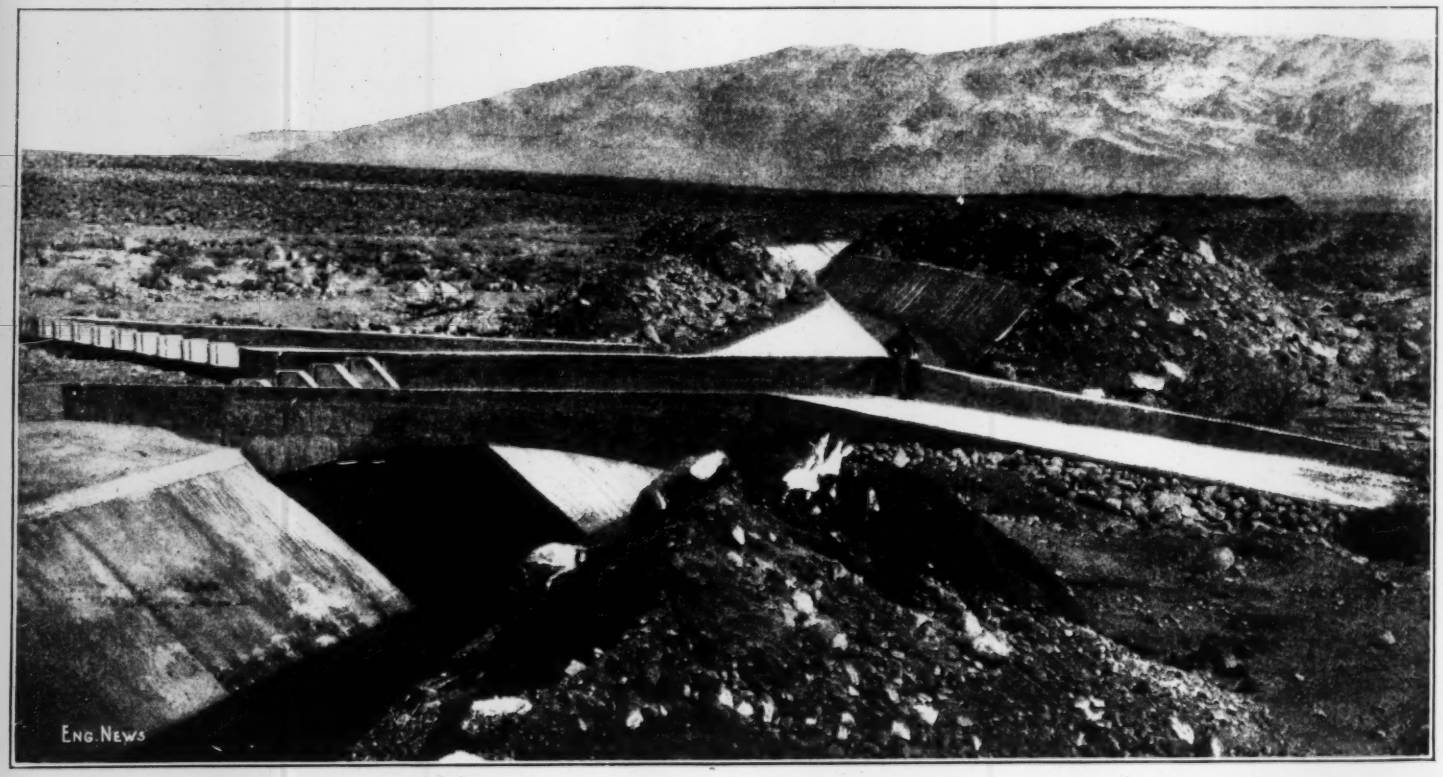


FIG. 7. CONCRETE-LINED OPEN SECTION OF THE LOS ANGELES AQUEDUCT IN THE HEART OF THE MOJAVE DESERT

From the Haiwee Reservoir south to the Fairmont Reservoir, a stretch made up of 137 miles of tunnels, conduits, and siphons, the rated capacity is 431 sec.-ft. The Fairmont Reservoir, situated at the northern edge of the Sierra Madre Range, is designed solely as a power regulating reservoir and has a capacity of 7620 acre-feet. From here the water passes beneath the Coast Range by means of 10,617 ft. of pressure tunnel of 1000 sec.-ft. capacity to provide for peak loads of power generation, to emerge on the south side of the range, and, emptying into a surge chamber, from there plunges down 941 ft. upon the power wheels of hydro-electric plant No. 1.

This plant, with a maximum capacity of 69,370 hp., is now under construction. The three units being installed will have a maximum capacity of 37,500 hp. and it is expected that the plant can be completed by late fall. From here the water will be carried 7 miles along the rim of San Francisquito cañon, in this distance to be shot down 512 ft. for the development of 44,100 hp., whenever the market will justify the installation of the neces-

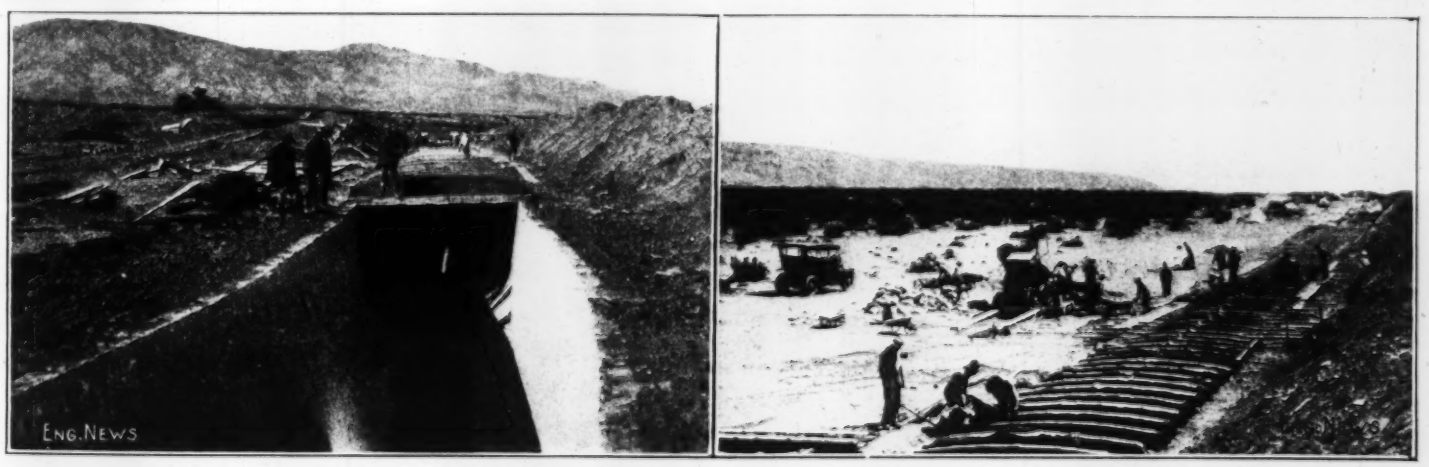
FIG. 8. A TYPICAL STRETCH OF FLAT-COVER AQUEDUCT; THROUGH ROSE VALLEY

sary machinery. After leaving the tail race of this proposed power plant the water flows into an equalizing basin called the Dry Cañon Reservoir, which has a capacity of 1325 acre-feet. From here, the Aqueduct as stated above, and of a capacity of 420 sec.-ft., takes its course through the rugged Santa Susanas to its outlet on the edge of the Fernando Valley, at which point its elevation is 1161 ft. above sea level. The elevation of the city's business district is approximately 276 ft. above sea level.

Here at the present time a cascade and water race is being constructed with two miles of conduits and two short tunnels carrying the water into the City Trunk Line and the Lower Fernando Reservoir, both of which are now under construction. The completed plan calls for a power drop of 294 ft., with a possible development of 10,000 hp. between the Aqueduct Outlet and the Upper Fernando Reservoir. This is a contemplated impounding basin of 15,940 acre-feet, with a surface elevation at 1275 ft., situated between the Outlet and the Lower Fernando Reservoir, which has a surface elevation of 1135 ft. above sea level and a capacity of 25,000 acre-feet. From the Intake to the Outlet it will be seen that the Aqueduct is a gravity system.

The plans of distribution with the building of at least two additional reservoirs are not in a stage to permit of even prophecy. However, the reader will visualize the whole system by seeing the Aqueduct as an arm, the San Fernando reservoirs as the palm of the hand and the trunk lines leading off therefrom as the fingers.

The carrying capacity of the Aqueduct is rated at 20,000 miner's inches (of southern California) or 259,200,000 gal. in 24 hours. Allowance of 1600 miner's inches was made for seepage, evaporation and other losses. Tests of nearly 100 miles of the Aqueduct made up to May, 1913, show that this provision for loss is more



FIGS. 9 AND 10. CONSTRUCTION OF COVERED CONDUIT, WITH RIBS, ACROSS THE MOJAVE DESERT

than ample and the system should be capable of delivering a quantity something in excess of the 20,000 miner's inches.

As to the quality: The purity of the water and its freedom from present or future contamination is unquestioned both because of its source and the fact that the 3000 miles of the Owens River drainage basin are so rugged as to remove any fear of pollution through growth of population in the valley. The supply will be made up about half and half of the waters of the Owens River and streams debouching from their mountain cañons directly into the Aqueduct. An analysis of the mineral content of Owens River and Black Rock Spring, the latter being a fair sample of the quality of the 34 streams, is herewith given:

	In grains per U. S. gallon	
	Black Rock Spring	Owens River at Aqueduct Intake
Sodium chloride	0.92	3.05
Sodium sulphate	1.97	4.47
Sodium carbonate	1.64	4.57
Calcium carbonate	3.42	7.71
Magnesium carbonate	0.64	1.26
Iron and alumina	0.23	0.36
Silica	0.16	0.54
Total solids per U. S. gallon	8.98 grains	22.96 grains

(Samples taken Apr. 19, 1912, submitted Apr. 23; reported Apr. 30, 1912. Analyses by Prof. Laird J. Stabler.)

The average mineral content of the new supply will, therefore, be about 15 to 17 grains per U. S. gallon. This as compared with most Eastern waters will show excessively high. With Western waters, however, the showing is very favorable. The mineral content of the present supply of the city is 31 grains per U. S. gallon. At this point and as a general answer to the many

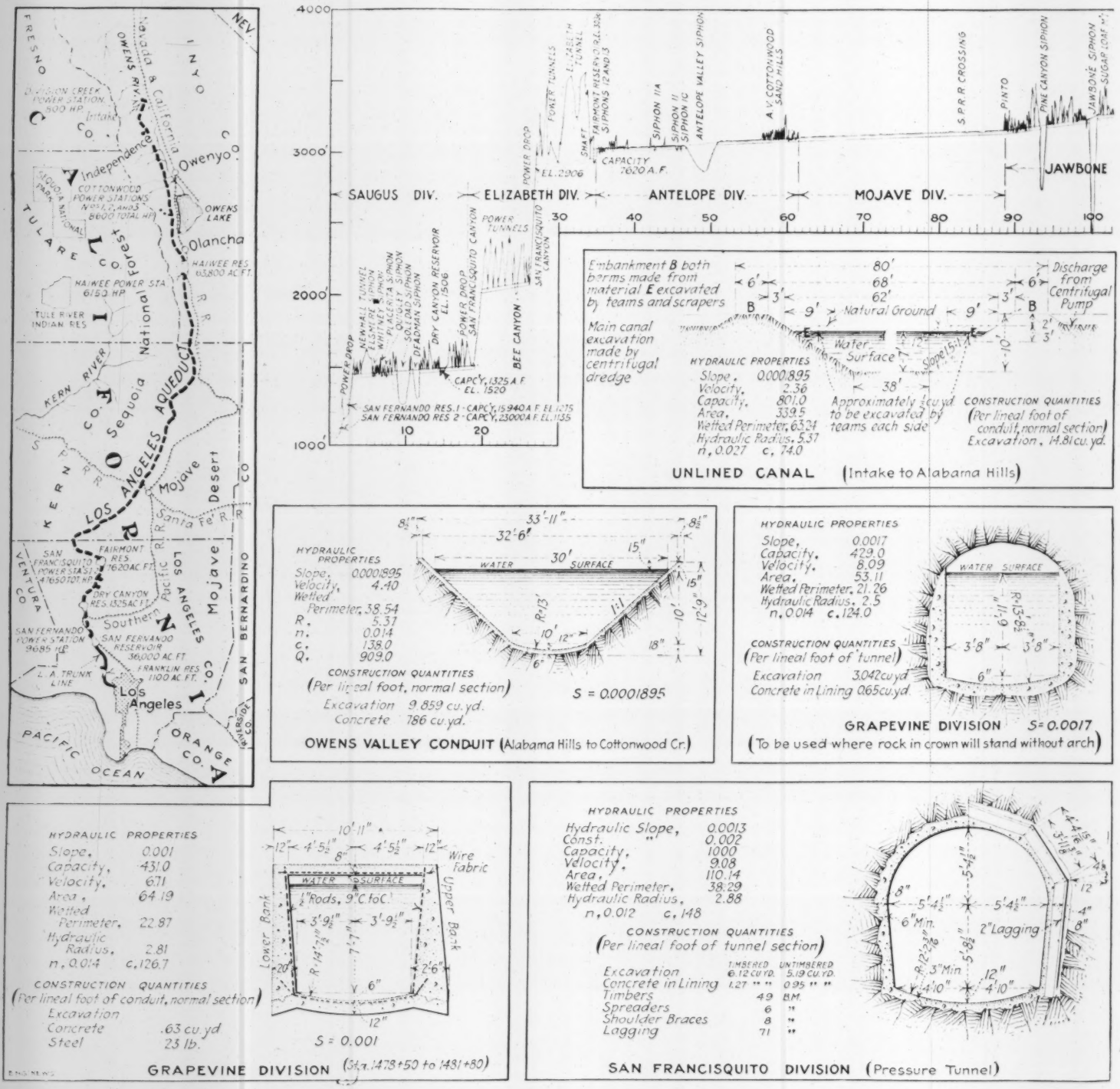


FIG. 11. MAP AND PROFILE OF LOS ANGELES AQUEDUCT, WITH TYPICAL CROSS-SECTIONS SHOWING OPEN CHANNEL AND TYPICAL SECTIONS OF CHANNELS AND

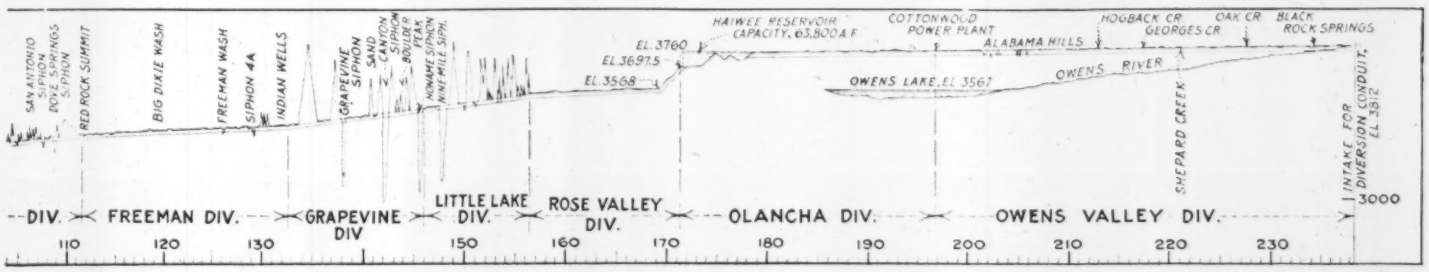
inquiries which the department has received, it may be well to state regarding the possible deterioration of the steel siphons that the water is of a character to cause a minimum corrosion of the material. The siphons are raised on concrete piers, are laid in a region of remarkably dry atmospheric conditions and have been coated inside and out with a heavy asphaltum liberally diluted with gas-works coal tar. In an extensive use of steel pipe of this character, extending over a period of 30 years, it has been Mr. Mulholland's experience that pipes

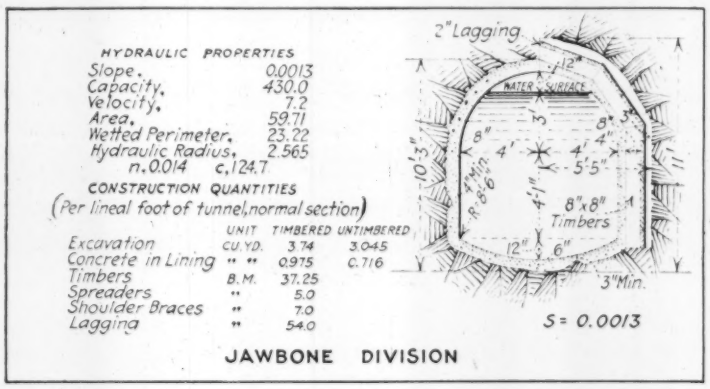
mer of 1908, is noteworthy, as will be seen by the following tabulation of the progress by years:

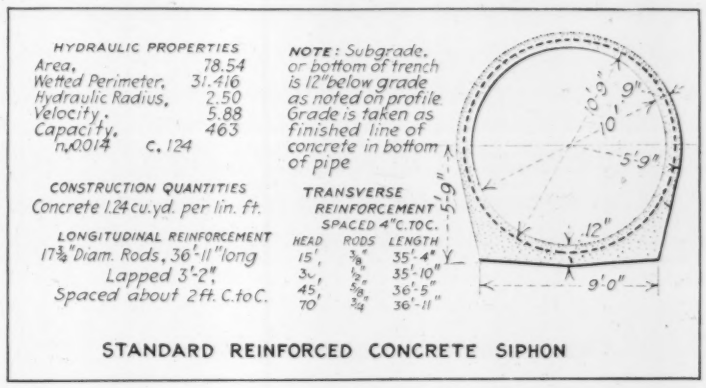
	Miles
Excavation completed to July 1, 1909	36.52
Excavation completed July 1, 1909 to July 1, 1910	65.36
Excavation completed July 1, 1910 to July 1, 1911	45.48
Excavation completed July 1, 1911 to July 1, 1912	48.38
Excavation completed July 1, 1912 to May 1, 1913	29.27
Excavation remaining uncompleted (power tunnel)	0.25

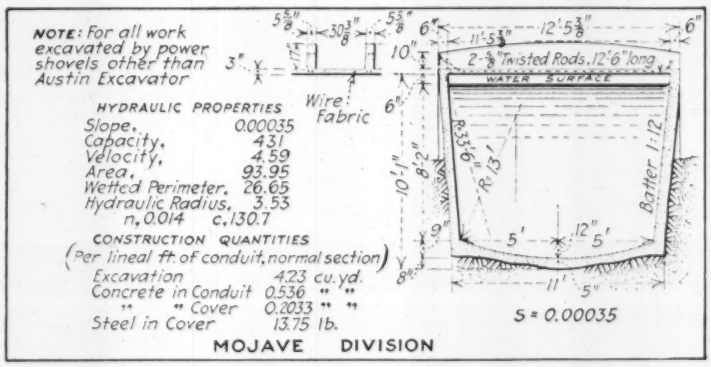
In the above siphon work is classed as "excavation."

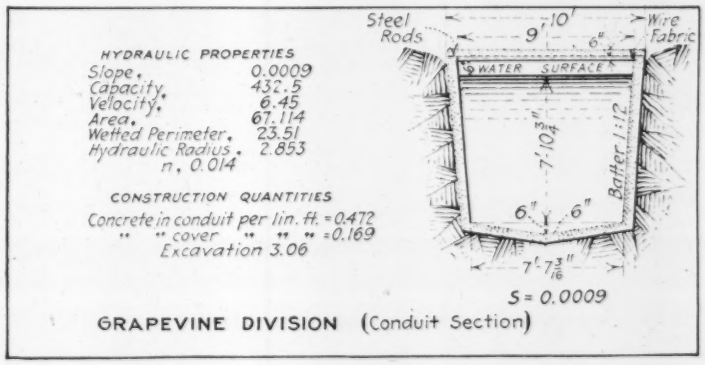
In concluding the brief description of the engineering features, the writer would draw attention to the difficult conditions under which the work was inaugu-

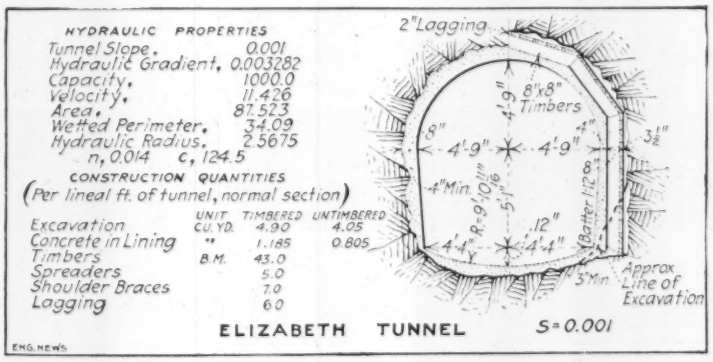





HYDRAULIC PROPERTIES
Area, 78.54
Wetted Perimeter, 31.416
Hydraulic Radius, 2.50
Velocity, 5.88
Capacity, 463
n, 0.014 c, 124
CONSTRUCTION QUANTITIES
Concrete 1.24 cu. yd. per lin. ft.
LONGITUDINAL REINFORCEMENT
17 3/4" Diam. Rods, 36'-11" long
Lapped 3'-2"
Spaced about 2 ft. C. to C.
NOTE: Subgrade, or bottom of trench is 12" below grade as noted on profile. Grade is taken as finished line of concrete in bottom of pipe
TRANSVERSE REINFORCEMENT SPACED 4" C. TO C.
HEAD RODS LENGTH
15' 3/8" 35'-4"
30' 1/2" 35'-10"
45' 5/8" 36'-5"
70' 3/4" 36'-11"
5'-9"
12"
9'-0"
STANDARD REINFORCED CONCRETE SIPHON







Unlined Ditch, Open Lined Channel, Covered Reinforced-Concrete Siphons

in the air with water constantly flowing through them show no appreciable deterioration in that period under our California conditions.

The rate at which the excavation of the Aqueduct has been carried on, following its beginning in the late summer of 1907, when the $23,000,000 bond issue was voted, to October of 1908 was required simply for preliminary construction, in which nearly 20% of the total amount voted was expended. The operations have been in or on the edge of a desert, originally far from human habitation and at first without methods of communication, transportation or even water-supply. The fact that the construction includes *52 miles of tunnels*, ranging from a few hundred feet up to five miles in length, tells briefly of the rugged, mountainous topography which was encountered for much of the way. To the foregoing must be added the difficulty of procuring labor in sufficient quantity, and once having obtained it to hold its employment under the adverse climatic conditions of the Mojave Desert.

To advocates of municipal ownership, the work is of particular interest from the fact that it is of itself a municipal project which in turn has involved many other fields of somewhat unusual municipal endeavor. These, in brief, may be summarized as follows:

Leasing and farming of as much of the land as is tillable of the 100,000 acres of property purchased in the Owens Valley to procure and protect the purity of the water-supply, these operations being carried on under the direction of the city's farm superintendent.

The inauguration of an extensive plan of forestation for commercial purposes on lands in the Owens Valley not suited to crops.

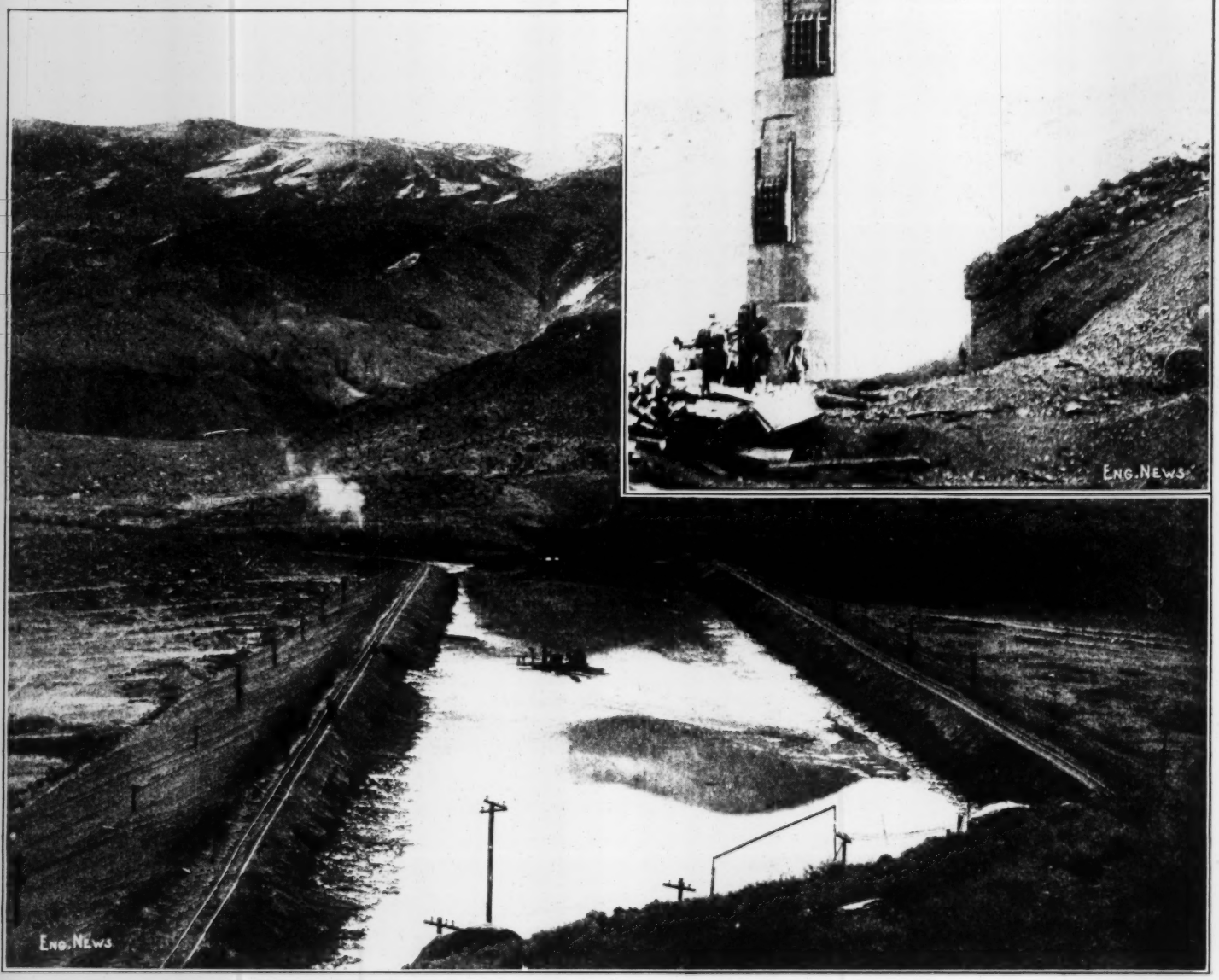


FIG. 12. BUILDING THE LOWER DAM OF THE HAIWEE RESERVOIR BY THE SLUICING PROCESS

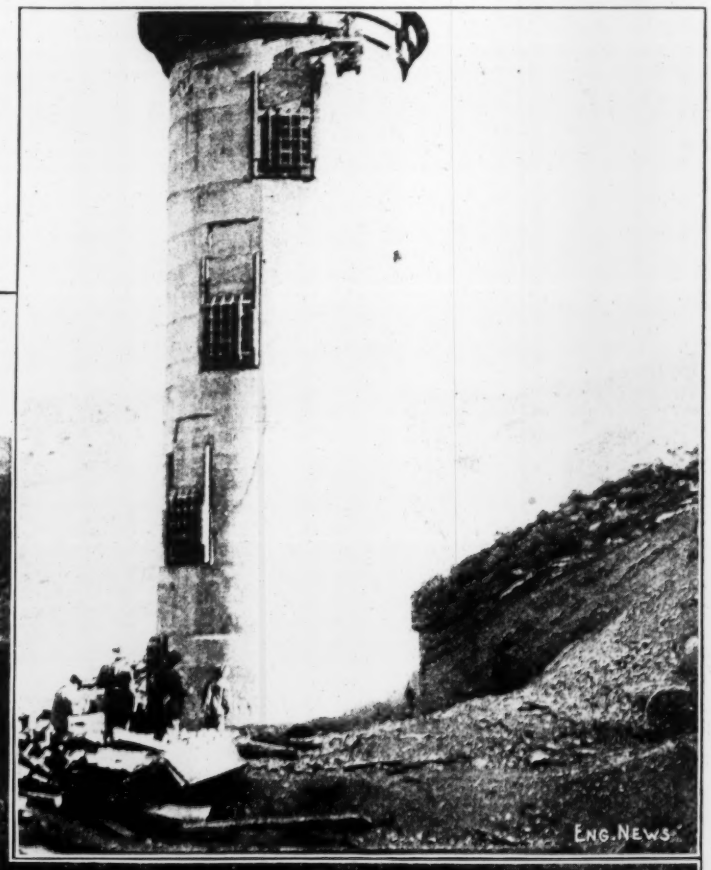


FIG. 13. GATE TOWER OF THE HAIWEE RESERVOIR

The position of the city as a corporate producer of electric power to supply communities without its own limits. This was brought about by the city's having surplus current from its two hydro-electric construction power plants in the Owens Valley and the sale of electric energy to the towns of Independence and Lone Pine for lighting and power purposes.

The ownership and operation of a municipal telephone line with 220 miles of main line and 240 miles of branches, switchboards, complete operating and maintenance force.

The manufacture of standard Portland and tufa cement (the latter being an innovation in the cement industry of this country) by the erection of one Portland mill and three tufa regrinding mills at an outlay of more than $900,000.

Last, but not least, the construction of the entire work with all side issues as a municipal proposition in which nearly all classes of day labor were practically taken into partnership with the city and paid a bonus whenever the progress was in excess of a stated average. The one exception to the above and exclusive of the commissary and medical departments was the construction of 9 miles of comparatively easy conduit and tunnel building let by contract at the opening of operations for the purpose of being able to arrive at a just comparison of economy between private and public construction. Based on the records of the cost-keeping department, the comparison shows that if the Aqueduct had been built under private contract it would have cost close to $40,000,000. Much salvage, including the Monolith cement mill, which is subject to purchase by Los Angeles County at a cost

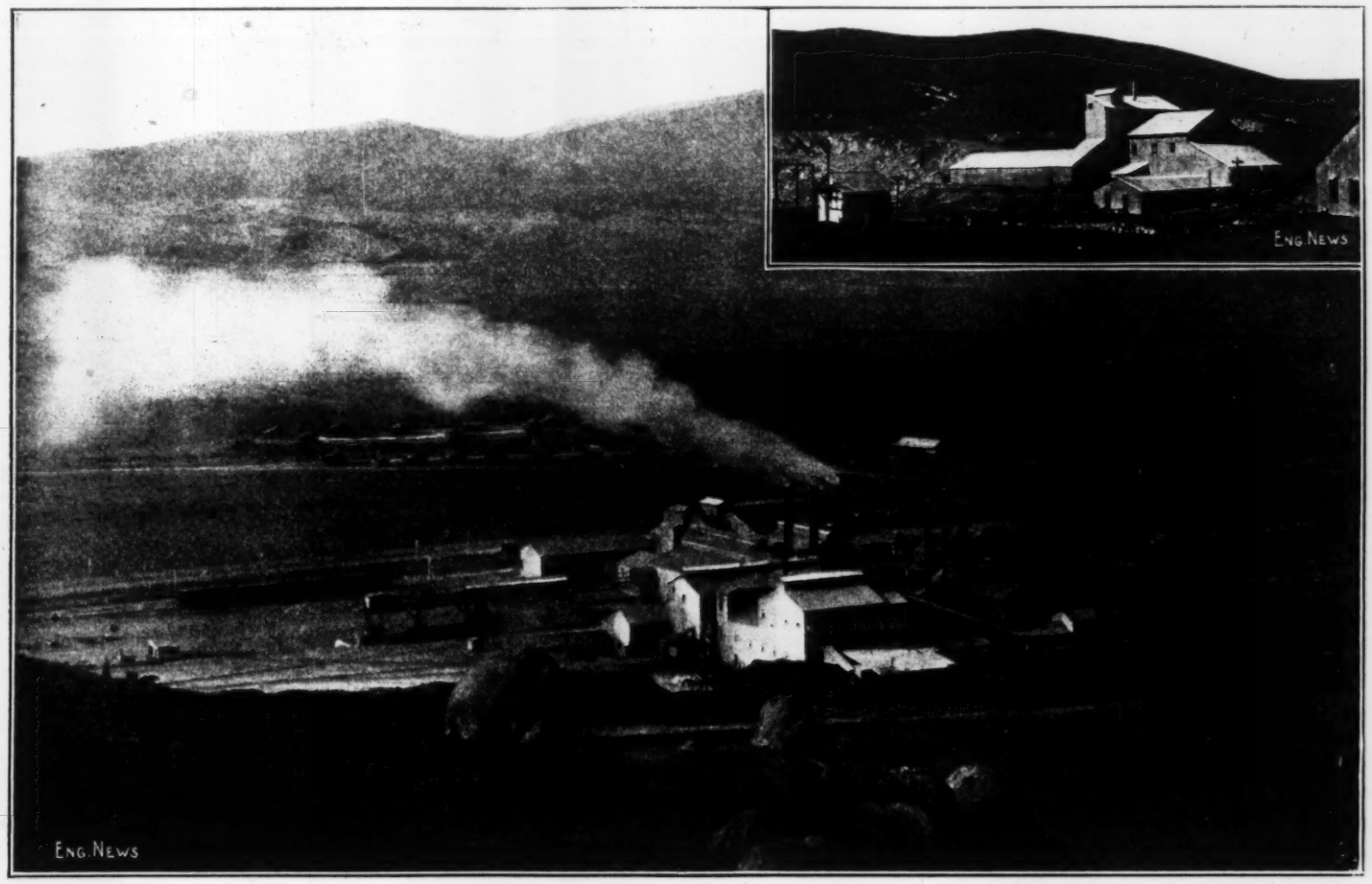


FIG. 14. MUNICIPAL CEMENT MILL AT MONOLITH, CALIFORNIA

(Much of the cement used on the Los Angeles Aqueduct was made by this mill. Its capacity was 1000 bbl. per day and its cost, with the tufa grinding mills shown in the other view, was about $900,000.)

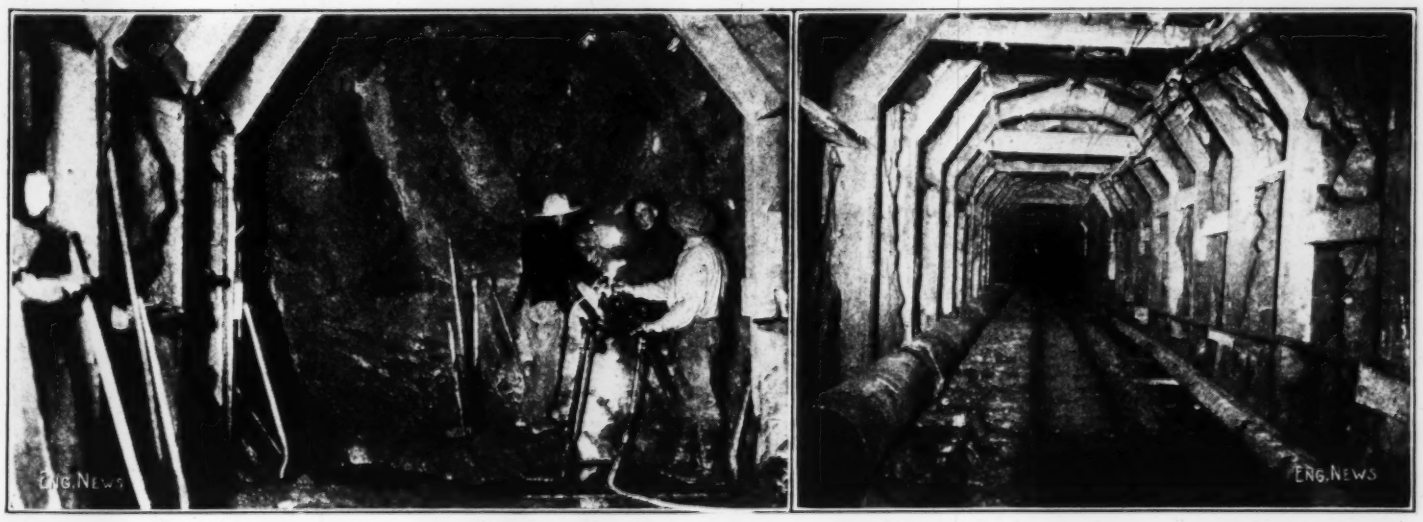
FIG. 15. TUFA REGRINDING MILL, LOS ANGELES MUNICIPAL CEMENT PLANT

(The tufa quarry and mountain shown in the background.)

of $550,000, remains to be disposed of, so that no statement can be given of the total actual cost, but it is safe to say that the project has been completed well within the total appropriation of $24,500,000, of which $1,500,000 has been expended for land and water rights.

Concerning the last phase of the subject, that of commercial utility, this journal has recently printed (March 13, 1913) an extensive article on the distribution and sale of surplus waters, and power development is not at a point where the comments as to possible sales will go farther than estimates. Where these are based upon conservatism they are of value and for this reason the writer presents a statement of the ultimate revenue capacity as prepared some months ago by J. B. Lippincott, assistant chief engineer of the Los Angeles Aqueduct Bureau.

In explanation of his rates on water it should be stated that the present rate for city domestic use is $9\frac{3}{4}$c. per 1000 gal. and that for the sale of surplus water he figured on the original plan of water distribution



FIGS. 16 AND 17. ELIZABETH TUNNEL, LOS ANGELES AQUEDUCT

(The tunnel extends for five miles beneath the Sierra Madre Range. Each view is taken at a point three miles from the portal. The speck of light in Fig. 17 is the portal.)

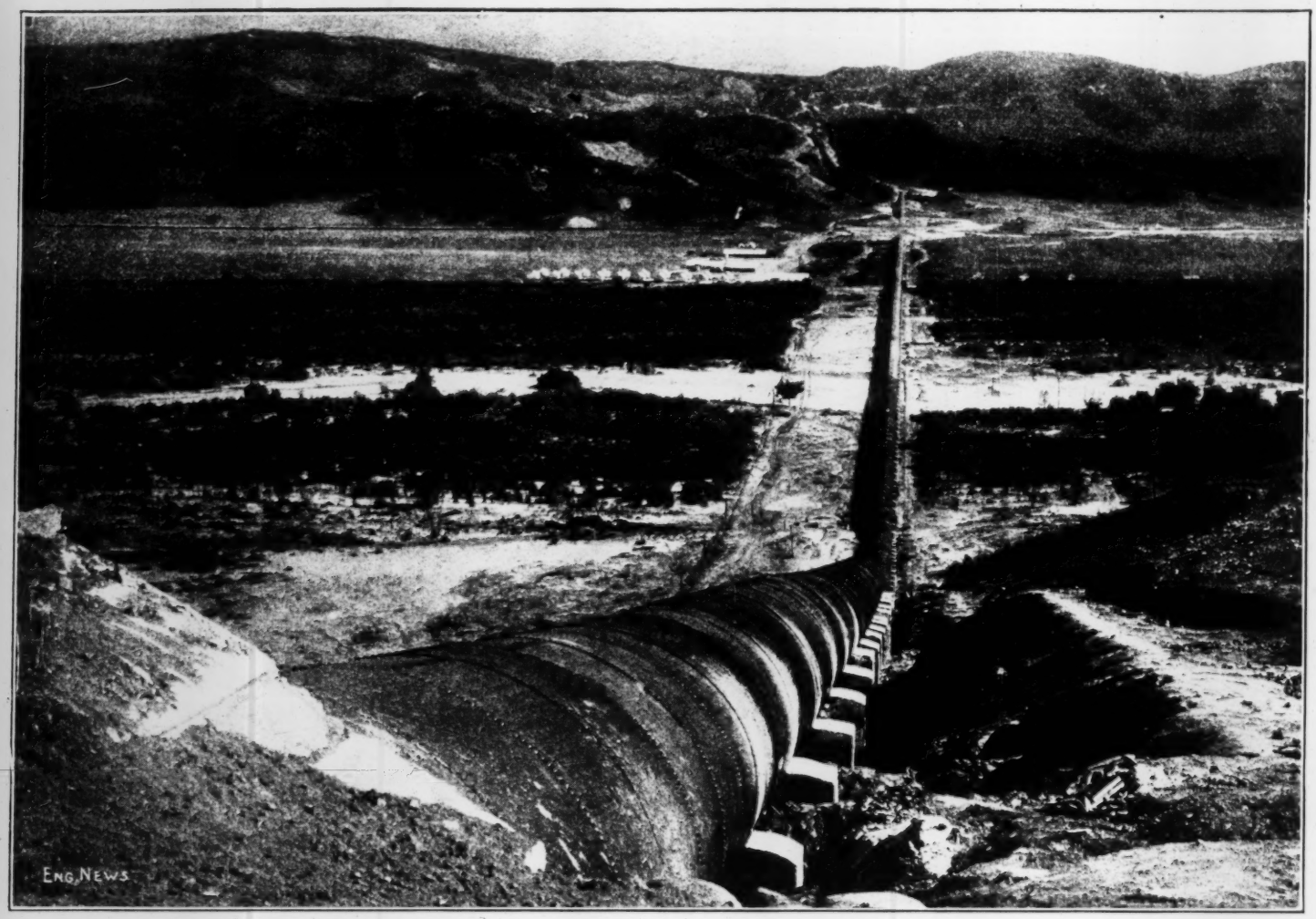


FIG. 18. SOLEDAD SIPHON, LOS ANGELES AQUEDUCT, LOOKING SOUTH

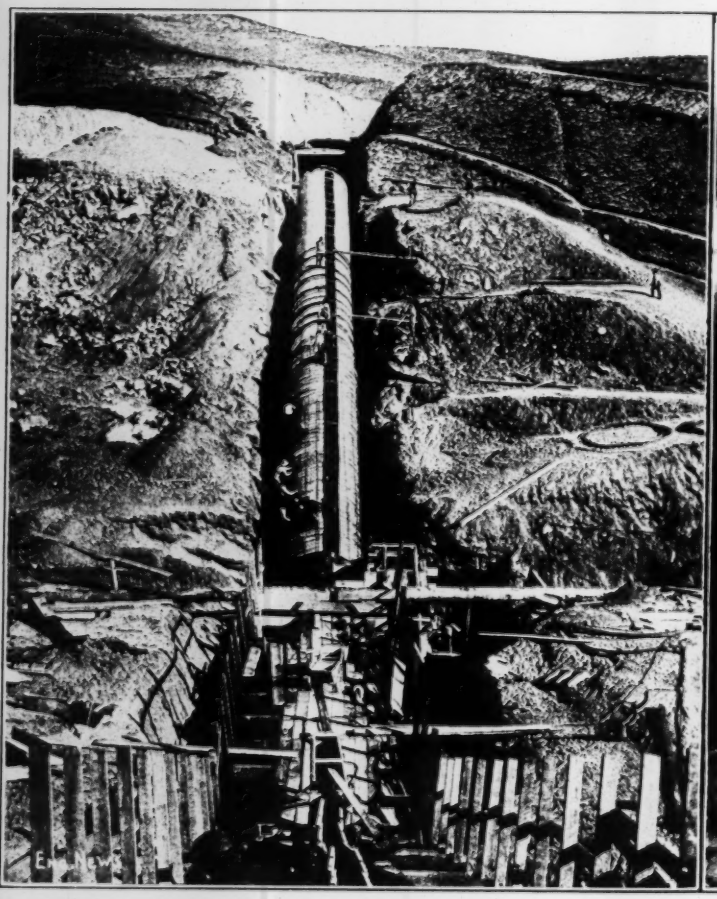


FIG. 19. WHITNEY REINFORCED-CONCRETE SIPHON

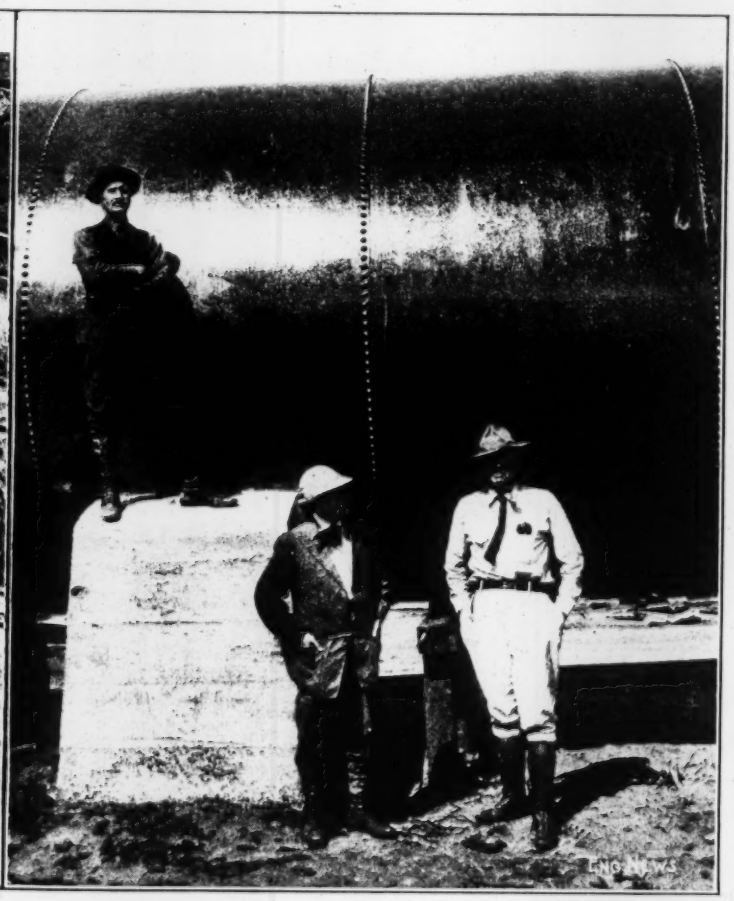
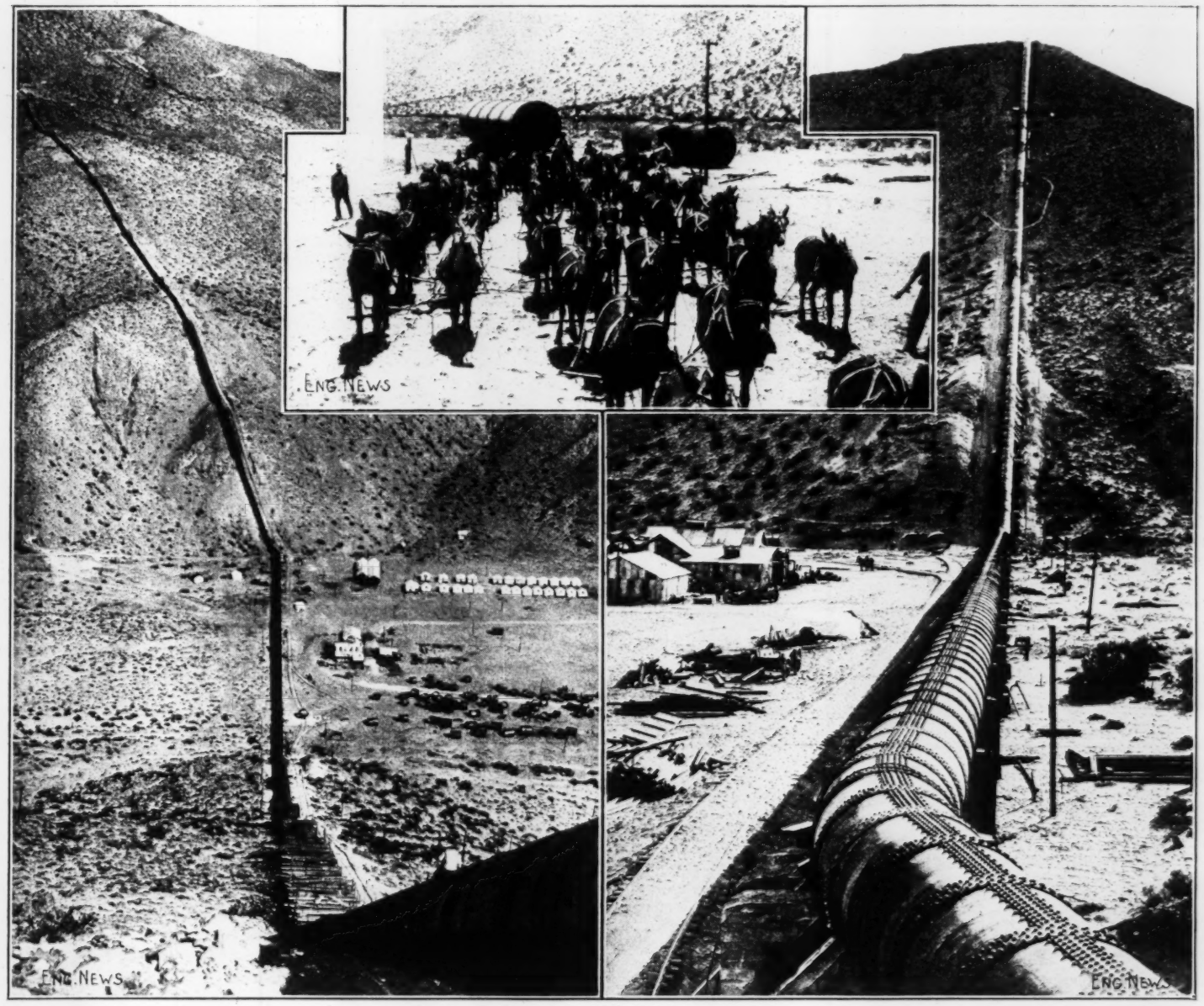


FIG. 20. DEADMAN STEEL SIPHON



FIGS. 21, 22 AND 23. JAWBONE SIPHON, LOS ANGELES AQUEDUCT, LOOKING SOUTH AND LOOKING NORTH; ALSO 50-MULE TEAM HAULING PIPE SEVEN MILES FOR SIPHON

(The siphon ranges from 7½ to 10 ft. in diameter and the steel plates are from ¼ to 1⅛ in. thick. The siphon is 8000 ft. long and its highest point is 850 ft. above the cañon bottom.)

in that all lines employed to distribute surplus water for irrigation should be constructed at the cost of the districts served. Moreover, he assumed the rate for irrigation as being $10 per acre per annum, whereas the City Council recently set the official rate at 2c. per in. per hour or $23.36 per acre per annum, the city to build the main trunk lines. Under this arrangement, nearly 2000 miner's inches of water were contracted for, on lands lying to the northeast of the municipality.

Mr. Lippincott, after estimating the whole cost of the Aqueduct and water properties at $24,500,000, assigns an estimate of cost of $7,000,000 to utilize all available drops on the Aqueduct for the production of 48,000 kw. of continuous power, with main power lines to the city of Los Angeles but without distribution, as per the estimates of the Board of Electrical Engineers. This would give $31,500,000 as the total cost of the Aqueduct as a water and power enterprise.

135,000 acres irrigated at $10 per acre, net	$1,350,000
30,000 acres irrigated with return water at $10 per acre	300,000
26,000,000 gal. per day of water sold from the Aqueduct for domestic purposes at a net profit of 5 c. per 1,000 gal.	475,000
48,000 kw. of continuous power *wholesaled* in city @ 0.6c. per kw.-hr, based on present condition of oil market	2,300,000
Total ultimate annual revenue	$4,425,000

Capitallized at 5% this is $88,500,000.

The revenues he estimates as shown in the accompanying table.

Also it will be seen from the foregoing that the revenues from water should tend to constantly increase until they had reached that point where all the surplus water once disposed of for irrigation is being taken for domestic uses at a very much higher rate.

Also, in the case of power development the figures are for wholesale delivery, and the city, if it is determined to build its distribution system, could expect a corresponding increase in net revenues from the additional labor and expense. On the whole, then, Mr. Lippincott's estimates are on the safe side of conservatism.

In conclusion, two economic and sociological phases of this great project which seem to have been entirely overlooked in all that has been written on the subject are these: In undertaking the construction of the Aqueduct, the city has established its future which as it pertained to

a water-supply and so additional population was in a precarious condition up to 1905. Realty values have been fixed firmly or advanced and a sound tone given to commercial enterprises. The writer believes that the enterprise, in the foregoing described way, has already paid for itself.

The sociological aspect is this: The responsibility of so great an undertaking at such a high cost in taxation to a city numbering less than 350,000 people in 1905, centered municipal attention upon the work, kept politics out, gave no time or opportunity for petty party or sectional strife, taught the community what could be done and gave it confidence in itself. One of the reasons

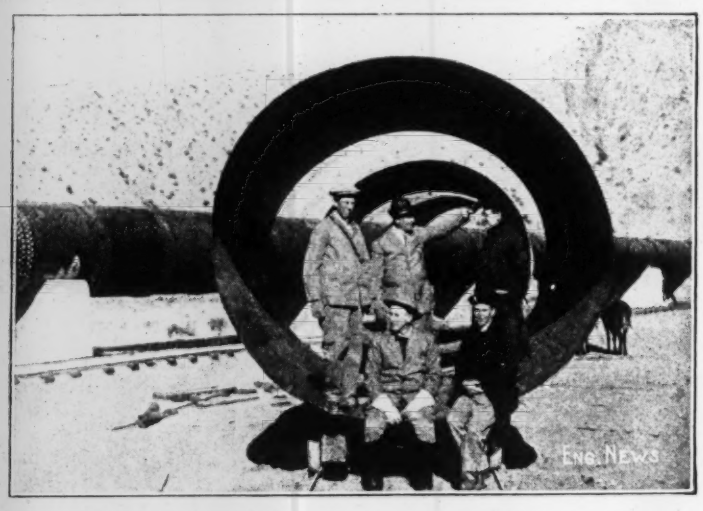


FIG. 24. A 10-FT. SECTION OF THE ANTELOPE STEEL SIPHON, LOS ANGELES AQUEDUCT

for the defeat of several recent proposed bond issues for municipal enterprises is directly due to the fact that many voters, while believing in municipal ownership, feared that the city was becoming overconfident of its present ability.

In the construction of the Aqueduct, William Mulholland, superintendent of the city's water distribution system for more than a quarter of a century, has served as designer and constructor, with J. B. Lippincott as his chief assistant engineer, Roderick MacKay as mechanical constructor and E. F. Scattergood as chief electrical engineer.

The Lighting of the Panama-Pacific Exposition buildings and grounds at San Francisco in 1915 is being designed on what are believed to be new lines for such work. Heretofore exposition lighting has been largely by outlining the prominent architectural features of buildings and grounds by strings of incandescent lamps. That has been abandoned in this case for the general scheme of projecting various colored streams of light upon the external surfaces. The use of colored light will be prominent, especially tones involving the reds, blues, oranges, and vermilion. High towers of the buildings will be set with large cut-glass jewels to reflect the light projected upon the building; many of these jewels will be spring mounted to increase their scintillation. All through the grounds, walks and roadways, there will be flaming-arc lamps with special heavy diffusing globes to keep the intrinsic brilliancy low. The open courts will be lighted also by large fountains with inner structures built up of dense glass and housing a multitude of arc lamps. There will be utilization of the day flags and bunting at night in the scheme to flood the structures with light. A floating battery of searchlights will play on the sea mists, which are met with in this locality, or upon artificial clouds of steam produced in clear weather, or upon a multitude of small balloons, etc., which may be sent up to get variety. The whole project of illumination design is under the direction of W. D'A. Ryan, of the General Electric Co., Schenectady, N. Y.

A Traveling Filter-Sand Agitator at South Bethlehem Pa.

The water-purification plant of the Bethlehem City Water Co., at South Bethlehem, Penn., was built in 1904 and is of the slow sand filtration type invented and installed by P. A. Maignen.* The water is obtained from the Lehigh River. The pumping station is on the river bank, but the reservoirs and filtration plant are located some distance away at an elevation of 265 ft. above the river.

From the upper raw-water reservoir the water runs by gravity to the filter house through a 20-in. main. The normal capacity of the filter plant is 4,000,000 gal. per day. The plant consists of six units of scrubbers, in concrete tanks 16 ft. wide, 38 ft. long and 6 ft. deep; and six units of slow sand-filtration beds 16 ft. wide, 152 ft. long and 6 ft. deep. Water enters the bottom of the scrubber beds through 8-in. valves and flows over a dwarf dividing wall to the slow sand filters. After filtering through the sand, the water flows out through effluent pipes at the bottom into the filtered-water reservoir, alongside and 20 ft. below the raw-water reservoir.

The scrubbers consist of a 9-in. layer of 3-in. pebble stones, and a 9-in. layer of coke; above there is a 24-in. space filled with 4 rows of slates, placed at a slight angle upwardly, each row slanting in a contrary direction to the next; the space between the slates is filled with coke of "nut" size. Over the slate is an 18-in. layer of sponge held down by cedar slats. The final sand filters consist of 18 in. of gravel and 24 in. of sand. The water filters through under a head of about 2 ft.

When the plant was first built, a special sand-washing device was constructed, consisting of a portable platform and an elevated washing trough. The sand was scraped off the surface of the beds, loaded on the platform and rolled to the washer by men walking on the division walls of the tanks. The washer consisted of four bucket-elevators on a suitable framework, and was operated by an electric motor. The dirty sand was shoveled into a hopper and carried to the elevated trough by a conveyor. At the trough the sand was thrown from the conveyor into the water; it was then dipped out and allowed to fall back into the trough successively by two other bucket-conveyors. The fourth conveyor raised the cleaned sand and carried it to a chute, from which it was distributed to the filter beds. The wash water entered from the far end of the trough and flowed out at the near end where the dirty sand entered. The flow of the wash water was so regulated as not to carry away much of the fine sand.

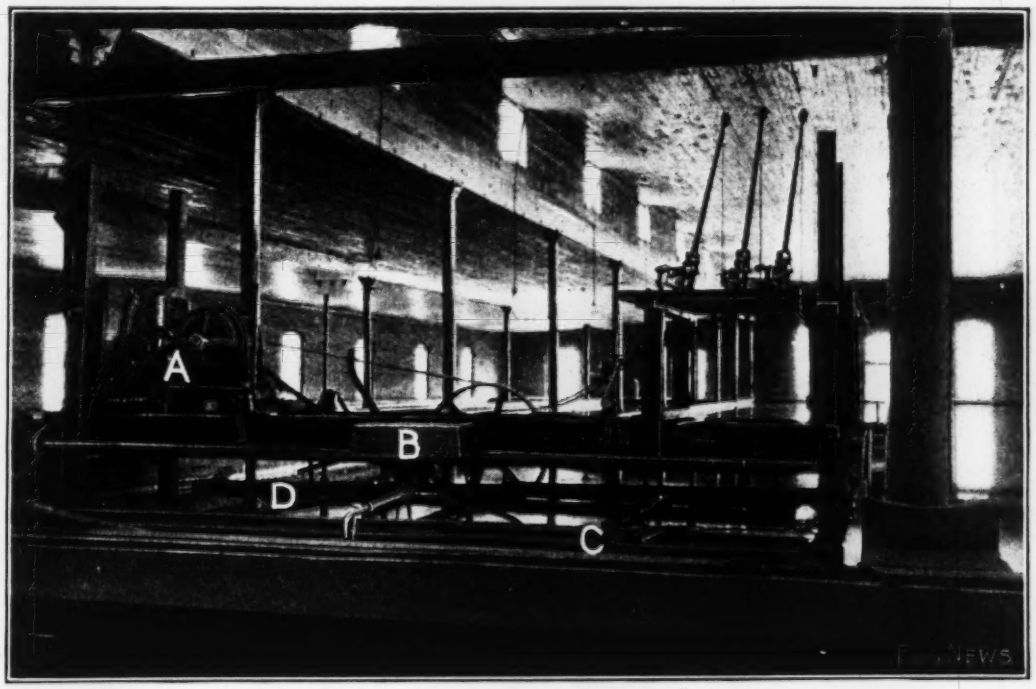
This machine proved cumbersome in practice, and the sand-washing process required a filter bed to be thrown out of service for practically a whole day. As the filtered-water reservoir holds but slightly more than enough water for 24 hours' consumption of the present population, either an enlargement of the filter plant or a more expeditious method of sand washing was imperative. Under these circumstances the superintendent of the water-works, H. M. Ueberoth, designed and built the washing machine shown in the accompanying illustration, with which a filter bed may be thoroughly washed in about 2 hours.

This machine accomplishes its purpose without lifting

*Described by P. A. Maignen in "Proceedings," American Water-Works Association, 1905.

the sand from the filter bed, by plowing up the upper 6 in. of sand by means of a heavy wire-toothed rake and two steel plow points about 8 in. long, while the actual washing is being done by water pumped from the filtered-water reservoir and forced back through the effluent pipes, up through the filter beds from the bottom, and out through wash water standpipes at the upper end of the beds nearest the scrubbers. For pumping the water back from the filtered-water reservoir a special electrically driven pump was installed at the lower end of the filter house.

The plowing apparatus is merely a framework of heavy timbers mounted on four flanged car wheels, which travel on a bar-iron track fastened to the inner edge of the filter tanks. The car is driven at a speed of 3 or 4 miles



Electrically Propelled Sand Agitator for Use in Washing Filter Beds, South Bethlehem, Penn.

an hour by a 10-hp. electric motor *A*, belted to a pulley wheel, to the shaft of which are attached the bevel gears *B*. The current for operating the motor is provided by three overhead trolley wires. Three wires and trolley poles are used so as to furnish a return circuit and to make it unnecessary to reverse the poles at the end of the run.

Two rakes are provided, one on both front and rear of the car. Each rake is hung from a heavy plank (*C* and *D*), which is raised and lowered from the surface of the sand by two vertical screws and crank levers. The rake itself resembles an ordinary farmer's hay rake, made of stout wire prongs, bent to an arc, about an inch between centers. The two plow blades are detachable and may be fastened at any point of the rake frame by iron brackets. They trail behind the rake at a distance of about 2 ft. Of course, the rear rake and plows only are in use while the machine is in operation. The whole apparatus is transferred from one bed to another by a small overhead crane.

This sand-washing device is home-made and designed to meet the peculiar conditions at the South Bethlehem plant. It has been in use over a year and has proved both efficient and economical, and is doubtless adaptable to use elsewhere. It is not patented.

The First American Locomobile

For nearly twenty years the self-contained and economical steam power plant known as the "locomobile" has been largely built in continental Europe. The outfit is generally arranged as follows: A compound engine is mounted upon its own boiler so that its cylinders are in the smoke box and the steam passes from a superheater directly to the high-pressure cylinder and from thence through a reheater directly to the low-pressure cylinder without any loss of heat from exposed piping. These locomobiles attain a fuel economy in small plants of 100 to 500 hp., equal to that of a large power station with high-class equipment. Furthermore, they are extremely compact, occupying very small space; and the cost of construction is cut down by the elimination of all steam piping and its accessories.

Notwithstanding the long and successful use of locomobiles on the continent of Europe, they have been little imitated in England and wholly ignored in the United States. Now, however, the first American manufacturer to produce this type of power plant, the Buckeye Engine Co., of Salem, Ohio, has undertaken the manufacture of these machines and their design is described by Mr. F. R. Low in a recent issue of *Power*.

The engine is mounted upon the boiler, superheater and reheater. Everything has been designed with a view to accessibility. The boiler is internally fired; and although it has a grate surface of only 9 sq.ft. and a heating surface of about 370 sq.ft., the unit has developed 200 i.hp. The furnace and tubes are removable for cleaning and inspection as in the German locomobile.

The gases after passing through the boiler tubes impinge upon the superheater and then the reheater, after which they escape. The space above the heaters is not shut off and the gasses are free to rise around the cylinders and thus tend to maintain in them as high a temperature as possible. Thus, instead of a steam jacket there is a hot gas jacket.

The course of the steam is from the dome into the far end of the heater, returning in a direction counter to the gas flow, passing into the high-pressure cylinder. From thence it passes through the reheater and into the low-pressure cylinder, whence it is discharged through the feed-water heater to the condenser.

In a recent test the engine developed an indicated horsepower on less than 9.75 lb. of steam per hour. The coal per indicated horsepower-hour varied from 2 lb. at 75 hp. to 1.5 lb. at 200 hp. With efficient loading, i.e., from about 60 to 100% of full load, the unit delivers a kilowatt for about 2.5 lb. of coal per hour, and an indicated horsepower-hour for about 1.5 lb. condensing and 2 lb. noncondensing.

Blended or Sand-Cements; Results of the Study and Experience of the U. S. Reclamation Service*

By Rapier R. Coghlan†

The term "blended cement" will be applied in this article to those hydraulic cements made by intimately blending in a tube mill, or other suitable blending machine, portland cement and certain varieties of natural rocks. It will exclude blast-furnace slags and natural cements. The manufacture and use of blended cements is of economic importance if suitable precautions are taken at the start, and its more general and widespread use will depend upon its ability to get engineers to look with favor upon it. Should it succeed, the people of the western deserts and mountains are assured of a cheaper and at the same time a reliable cement.

Sand-cement made by blending portland cement and quartz sand has been used to a limited extent in the United States.‡ Its use was discontinued, however, because of the decreased cost of portland cement making its production unprofitable. Concrete structures in which it was used do not appear to have suffered because of the substitution. That the cement was as strong as the portland cement which was used in its manufacture was probably due to the fact that at that time the standard of fineness for portland cement was much lower than at present, and for this reason a greater amount of inert clinker was rendered active by the fine grinding necessary to produce the sand-cement. As will be pointed out later, quartz sand is not a suitable material for the production of a high-grade sand-cement.

Some rocks, mostly of volcanic origin, have more or less silica existing in what is known to chemists, and nowadays to most engineers, as soluble or colloidal silica. This colloidal silica acts as a weak acid and has the power to neutralize bases. Portland cement is a complex mixture of various silicates and aluminates of lime with lesser amounts of secondary minerals. The process of setting may be described as follows, although it must be admitted that the knowledge of the subject is still very incomplete. In setting, portland cement undergoes a decomposition, reacting with water to form more stable compounds, and at the same time liberating hydrated lime. As the reaction takes place in a concentrated solution, the hydrated lime thus set free crystallizes throughout the mass, serving to bind it together more firmly. As portland cement is readily hydrolized if too much water is present, it is not possible to study the reaction in dilute solution, but the fact is established that hydrated lime is always liberated by the reaction.

Hydrated lime is a well known base, and it seems probable that if some substance with acid properties and from which an insoluble compound would be formed was present in the portland cement at the time it was undergoing the change caused by the addition of water, the hydrated lime thus set free would unite with this substance. Here then, is the basis upon which sand-cements or blended cements are formed. Rocks containing active or colloidal silica are blended with portland cement to furnish the necessary neutralizing compound and the result is a sand-cement.

Chemical analysis reveals the fact that several of the igneous and intrusive rocks have colloidal silica in varying amounts. It is also present in sandstones, the cementing material of which is deposited silicic acid. For obvious reasons limestones and dolomites are not sources of soluble silica, nor is quartz found to yield much even after prolonged fine grinding. In the light of our present knowledge it is also probable that the alumina in the aforementioned rocks reacts to some extent as a colloid and enters into the combination with the hydrated lime, acting as an acid and yielding an insoluble compound. This is a point which has not been definitely determined and is not here stated as a fact. Furthermore, the alkali oxides which are always present in igneous rocks play an important part in the reactions involved in the setting and hardening of sand-cements.

A glance at Table I below shows the wide range of materials that have been tested and found to yield satisfactory blended cements. The materials represented by Analyses 3, 4, 6, 7, 8 and 9, are being used at the present time for the production of such cements by the Los Angeles Aqueduct engineers and the U. S. Reclamation Service. Analysis 10 represents a pure quartz which after prolonged grinding, so that all of it passed the 200-mesh screen, yielded only 1.64% soluble silica. It will be noted that the soluble or colloidal silica has no definite relation to the composition of the rock, more probably being dependent upon the phenomena accompanying the formation of the rock. The lava flow from which the material for Analysis 2 was taken, shows clearly the action of steam during its ejectment, while the material for Analysis 1 was from a flow which had come to the surface more quietly.

The colloidal silica in materials like these makes them valuable for sand-cement manufacture. It is unquestionably true that more of the silica of the blending material is rendered active by the fine grinding necessary to produce an intimate mixture of the portland cement and sand material, thus furnishing more acidity to neutralize the basicity of the hydrated lime.

Before accepting as true any statement regarding the reaction between hydrated lime and colloidal silica, we should first ascertain if there be any substantial proof of the same. We have historical record that similar cements were made by the early Romans, but old records are apt to become musty and confused. A modern determination and one that could be applied by anyone desiring to do so would be more satisfactory.

TABLE I. CHEMICAL ANALYSES OF ROCKS FOUND SUITABLE FOR MAKING BLENDED CEMENT

	1	2	3	4	5	6	7	8	9	10
SiO_2	44.72	48.08	74.88	74.64	75.66	72.32	50.96	80.52	82.40	99.60
Fe_2O_3	14.30	16.06	1.14	1.14	2.12	2.01	6.57	2.00	1.40	0.31
Al_2O_3	19.26	15.39	13.60	13.42	11.76	13.85	18.37	10.02	10.00	
CaO	8.30	7.78	0.90	0.80	2.30	1.20	10.20	0.80	0.80	....
MgO	7.48	6.64	0.37	0.39	1.78	0.39	0.45	0.71	0.61	....
K_2O	2.30	1.60	3.89	3.86	None	N.D.	3.92	3.85	1.31	....
Na_2O	2.00	3.20	3.35	3.38	None	N.D.	....	....	0.86	....
SO_3	None	None	None	None	None	0.31	None	None	None	....
H_2O CO_2	1.64	1.89	0.88	1.66	5.42	3.78	7.26	2.10	1.90	....
Colloidal (Soluble) Silica	12.57	19.00	2.41	2.37	14.60	4.01	12.98	7.18	6.42	1.64

Analysis No. 1. Basalt from near Elephant Butte, N. M.
Analysis No. 2 Basalt from near Elephant Butte, N. M.
Analysis No. 3. Granite from near Boise, Idaho.
Analysis No. 4. Granite from near Boise, Idaho.
Analysis No. 5. Tufa from near Elephant Butte, N. M.
Analysis No. 6. Tufa from Los Angeles Aqueduct.
Analysis No. 7. Basaltic tufa from Lahontan, Nevada.
Analyses No. 8 and No. 9. Sandstones from Elephant Butte, N. M.
Analysis No. 10. Quartz—90% passing 200-mesh sieve.

*See "Engineering News," Mar. 20, 1913, p. 562; "Sand-Cement as Used by the U. S. Reclamation Service."

†Manufacturing Cement Chemist, U. S. Reclamation Service, Elephant Butte, N. M.

‡See "Engineering News," Feb. 15, 1912, p. 305; Apr. 16, 1896, p. 252.

Dr. Michaelis has shown that such a combination does take place between hydrated lime and puzzolanic materials, and that the mixtures are capable of developing considerable strength, even when immersed in water, the solvent action of which on hydrated lime is well known.

The writer has tested this reaction for himself with most of the materials with which he has been experimenting for sand-cements. The routine method employed in the laboratory has been to mix one part by weight of hydrated lime with one part by weight of the material whose activity is to be tested. In many cases these proportions are not correct, sometimes giving too much lime and sometimes not enough. The blend is then ground to a fineness of 90% passing the 200-mesh sieve. This combination is then made into briquettes with standard testing sand in the proportions of 1 : 3 by weight. After setting or hardening the briquettes are placed in water until the test period is due. Sometimes the action is weak at seven days and occasionally briquettes fall to pieces during the immersion period; but, in general, the materials which have given the best results in sand-cements have developed strength at 28 days and continue to gain.

These tests have generally shown that the materials which develop the most activity with hydrated lime are those containing the oxides of sodium and potassium in an available form. The ready solubility of the oxides of the alkali metals present in igneous rocks, eruptive and intrusive, can be shown by shaking some of the rock powder in water to which a few drops of alcoholic solution of phenol-phthalein have been added. The solution immediately assumes a pink color, which increases in depth as the solution of the alkalies proceeds. Puzzolanic action, the action between colloidal silica and hydrated lime, seems dependent upon the presence of the alkali oxides which probably act as catalyzers in the following manner:

Sodium oxide will be taken as an example. The sodium oxide combines with water to form the hydroxide. The hydroxide reacts with silica to form sodium silicate, or water glass, which is soluble. The water glass then combines with hydrated lime to yield insoluble silicate of lime, setting free the sodium hydroxide, which continues to render more silica active for the combination with the lime. In this manner, a small amount of sodium oxide, which is in the nascent state, seems capable of rendering a much larger amount of silica active.

$$Na_2O + H_2O \overset{//}{=} 2\ NaOH \qquad (1)$$

$$2\ NaOH + SiO_2 = Na_2SiO_3 + H_2O \qquad (2)$$

$$Na_2SiO_3 + Ca(OH)_2 = 2\ NaOH + CaSiO_3 \qquad (3)$$

This action has been tested by the writer in the case of a sandstone, which contained alkali oxides, that were not in the available form, being combined with SO_4 and Cl. This sandstone would not develop puzzolanic action when mixed with hydrated lime. Upon adding a small percentage of sodium silicate to the water used in mixing the mortar, puzzolanic action was developed and the briquettes continued to increase in strength.

A study of the analyses of Italian puzzolans shows that they contain a considerable percentage of sodium and potassium oxides. According to the foregoing, puzzolanic mixtures should continue to increase in strength until the maximum amount of silica had combined with the lime. An essential feature of such a combination is the necessity for keeping the mixtures moist during the early period of hardening.

It will be seen from the foregoing that in sand-cement we should have a maximum amount of lime combined with silica. Therefore the blending of any of these colloidal silica-bearing rocks with portland cement should have a tendency to produce a stronger and more durable cement for use in concrete work. The presence of the alkalies within the cement itself should act as an antialkali to the alkaline salts present in water. The reduction in the amount of lime existing in the set cement as hydroxide is in itself beneficial as it lessens the danger of disintegration from the action of alkaline waters. Another factor contributing to the combination between the hydrated lime and silica is the fact that the hydrated lime set free from the portland cement is in the nascent state and therefore more active and ready to combine with whatever is present. Danger of disruption of concrete in which sand-cement is used, by oxidation of the sulphides so commonly present in artificial puzzolans is not to be feared, as there is at the most but a slight amount of sulphur in any form present in the rocks which are suitable for the manufacture of sand-cement.

There is no foundation for the statement that the strength of blended cements is due to the finer grinding of the portland cement which they contain, and to the filling of the voids in the portland cement with the blending material. Portland cement of a fineness of 80% passing the 200-mesh sieve, having a specific gravity of 3.140, showed the following void tests: Settled and tamped voids, 40%; slightly settled, 47%; loose, 51.5%. The same cement made into sand-cement with granite gave the following void tests: Settled and tamped voids, 45%; loose, 60%. The voids in blended or sand-cement are the same or greater than the voids in the portland cement from which it is made, which is in accordance with the laws of voids, that the finer and more nearly uniform in size particles become, the greater may be the percentage of voids expected. A considerable reduction in volume takes place when blended cements are mixed with water, on account of the air being forced out of the cement and a rearrangement of the particles taking place.

Manufacture of Sand-Cement

We now come to the question of the manufacture of sand-cement, and must, therefore, know under what conditions we can obtain the best grade of sand-cement possible from the materials at hand.

The tendency of most eruptive rocks is to undergo alteration to clay or claylike substances under the action of meteoric agencies. This condition is easily recognized by chemical, microscopical and other physical inspection. The most important test, after satisfying one's self that the material is but slightly altered from its original condition, is to determine the colloidal silica content. Rocks which show no colloidal silica present should be abandoned as they cannot be relied upon to produce a good quality of sand-cement. These things being satisfactorily settled, the experimenter or manufacturer is ready to undertake the production of the desired product.

The proportion in which to blend the rock with the portland cement is dependent upon the strength desired in the concrete in which the product is to be used. With rocks rich in colloidal silica, the portland cement

may be very low, while with other rocks it may be necessary to maintain the proportion at one to one. The results of the physical tests of the product will govern the user in the amount of portland cement to be blended with the rock, and he should be the one to dictate to the manufacturer what these proportions shall be in his particular case.

Rocks which have been found suitable for sand-cement, and which are fruitful sources of colloidal silica, vary in specific gravity from 2 to 3.05. Generally speaking, one barrel of portland cement blended with an equivalent volume of any of the materials will yield on grinding slightly more than two barrels of sand-cement. The usual method followed in the manufacturing process is to prepare the rock by passing it through a ball mill or other pulverizer, which reduces it to a fineness of 100% passing the 20-mesh sieve. Finer material than this does not seem to blend well with the portland cement in the tube mills. It would even be better to take cement clinker and prepare it with a ball mill, rather than use the finely ground cement.

The question arises as to whether the materials should be blended by weight or by volume. As an illustration, take the case of granite which is to be blended with portland cement.

Voids in the pulverized granite = 42%.
Specific gravity of the granite = 2.630.
Weight per cu.ft. at mixing hopper = $2.630 \times 62.5 \times 0.58 = 95.5$ lb.
Voids in Portland cement = 51.5%.
Specific gravity of cement = 3.140.
Weight per cu.ft. at mixing hopper = $3.140 \times 62.5 \times 0.485 = 95.4$ lb.

As the materials have the same weight per cubic foot in the loose condition in which they arrive at the mixing machine, it is obviously immaterial whether the blending be done by weight or by volume. The machinery for measuring by volume being very simple, that method is employed in this particular instance. The proportions in the blend are checked by specific gravity and weight tests.

Basalt ground under the same conditions as the granite gave the following analysis:

Voids in basalt = 42%.
Specific gravity of basalt = 3.050.
Weight per cu.ft. at mixing hopper = $3.050 \times 62.5 \times 0.58 = 110.8$ lb.
Weight of cement at mixing hopper = 95.4 lb.

In this instance it would be best to proportion by weight as the greater weight per cubic foot of the basalt would cause an excess of basalt and might overcrowd the cement.

The assumption is made in the two preceding cases that it is desired to mix half and half. With materials of low specific gravity, like some of the tufas, which run as low as 2.20, it is best to proportion by volume as the weight method will give too large a bulk of material for the cement to cover. This would be governed, however, by the activity of the material in question, as material that is rich in colloidal silica, can be made into an excellent grade of sand-cement with a much smaller proportion of portland cement than would be required with material that showed only a small amount of this valuable compound.

Since one barrel of portland cement blended with an equivalent volume of any one of the materials mentioned, will yield a little more than two barrels of high-grade sand-cement, it is apparent that the cost of a barrel of sand-cement thus made, should be about two-thirds of the cost of a barrel of straight portland cement. The economic value of this cannot be overestimated in remote places where large quantities of cement are being used. A regrinding and blending plant for the manufacture of sand-cement at the rate of 1000 bbl. per day can be erected and ready to operate for about $15,000. Such a plant will require about 400 hp. to operate it. Labor will depend upon the wages current in the locality in which the plant is operating.

The Rio Grande Project of the U. S. Reclamation Service, located at Elephant Butte, N. M., will require about 520,000 bbl. of cement in the next three years. This cement will be used in the erection of the Elephant Butte Dam,* which is to store water for the irrigation of lands lying along the Rio Grande in New Mexico, Texas and old Mexico. It is proposed to use sand-cement in the construction of this dam. A sand-cement plant, in which portland cement will be blended with 50% by volume of sandstone has been erected at a cost of approximately $18,000. Power is furnished by a steam power plant at about 1¾c. per kw.-hr. Labor runs from $1.50 per day for Mexican laborers to $4 per day for skilled laborers. The cost sheet for the manufacture of the sand-cement will show

0.5 bbl. of Portland cement @ $2.50	$1.250
Sandstone	0.035
Plant charge	0.092
Labor	0.068
Supplies	0.055
Power	0.184
Cost of 1 bbl. of sand cement	$1.684
Net saving per barrel by using sand cement	$0.816

From the results of tests of the blends of this sandstone with lesser amounts of portland cement, it is probable that the percentage of portland cement may be carried as low as 40%. The U. S. Reclamation Service has studied sand-cements for over six years and the determination to try it out in such structures as the Elephant Butte and Arrowrock Dams, was reached after mature deliberation. Completely equipped testing laboratories have been installed at Arrowrock, Idaho and Elephant Butte, N. M. Sand-cement is tested even more rigidly than portland cement. Aside from the usual routine tests that are employed in testing portland cement, compression tests are made daily of the concrete being placed in the dams, and it is hoped that the building of these structures will furnish very complete data regarding sand-cement in actual use. It has been claimed by some that sand-cement concrete is more impervious to water than ordinary portland-cement concrete, this has not been substantiated by results actually obtained, but it is true that it is just as impervious as portland-cement concrete when used in the same proportions and under the same conditions. There is no valid reason why it should be more impervious than portland-cement concrete, but every reason why it should resist the action of alkaline waters much better.

The practice in the U. S. Reclamation Service laboratories when making experimental sand-cements has been to grind the blends so that just 90% of the product will pass the 200-mesh sieve, it being considered impracticable to carry the fineness greater than this. All experiments were designed to duplicate as nearly as possible the conditions that would be met in the actual manufacturing process on a commercial scale. For this reason the results of tensile tests given in Table II may not be as high as the results reported by others who have experimented on sand-cement mixtures. The cements thus

*"Engineering News," Jan. 16, 1913, p. 118.

made were tested only in the shape of briquettes, using the standard proportions of 1:3 with standard testing sand. The blends were tested for fineness, setting time, specific gravity and soundness. Two-inch cubes of the standard mortar were tested for compression. The normal consistency test showed that excepting the cements in which tufa was used this property was nearly the same as with the portland cement employed in making the blend. The setting time was changed but little, excepting in certain mixtures where the material was not very active.

TABLE II. TENSILE STRENGTH (LB. PER SQ.IN.) OF SAND-CEMENTS WITH DIFFERENT PROPORTIONS OF GROUND ROCK

Nature of rock	Per cent. of rock	7 day	28 day	3 mon.	6 mon.	1 year
Basalt	35	230	365	385	480	490
Basalt	40	180	330	395	425	460
Basalt	45	195	315	395	445	475
Basalt	50	135	300	385	425	415
Basalt	55	150	280	340	380	385
Basalt	60	130	215	370	390	400
Basalt	70	95	240	285	330	350
Basalt	80	60	165	195	235	332
Tufa	50	225	380	515	530	585
Tufa	60	140	255	460	522	535
Tufa	70	150	230	405	420	452
Sandstone	40	225	380	405	420	445
Sandstone	50	240	310	360	380	385
Sandstone	60	125	245	290	340	350
Portland cement	0	245	460	500	395	300
Portland cement	0	235	355	385	385	390

The same brand of portland cement was used in all of the tests shown in Table II and in many of the characteristics of the sand-cements are quite similar to those of the parent cement. In order to test the assertion that the finer grinding of the portland cement was responsible for the strength of sand-cements, some of this brand, which was normal in every respect, developing the strength shown by the test headed "portland cement," was ground so that 90% of it passed the 200-mesh sieve, with the results, when tested, shown by the first test headed "portland cement." This test, which was duplicated a number of times with the same result, indicates that when used by itself, this particular brand should not be ground as fine as 90% through the 200-mesh sieve, but gives much better results at its normal fineness of about 80% passing this sieve. Whether this is true of all portland cements ground to an abnormal fineness is now being tested and the results will be published if they bear out the foregoing.

A few compressive tests of mortars in which sand-cement has been used (Table III) will serve to show that it is equally efficient when used in compression. The mortars tested were of 1:3 mix with standard testing sand.

TABLE III. COMPRESSION STRENGTH (LB. PER SQ.IN.) OF SOME 1:3 SAND-CEMENT MORTARS

Nature of rock	Per cent. of rock	7 day	28 day	3 mon.	6 mon.
Sandstone	50	2167	3437	3750	4063
Sandstone	50	1500	3312	2500	4000
Sandstone	50	1000	2315	2750	3500
Sandstone	60	800	1390	1439	1875

The purpose of this article is not to quote a mass of data regarding the strength of experimental mixtures. The real proof of a cement is what it can do when made into concrete where the ratio of cement to inert material is quite small. If it can hold together nine parts or more of sand and gravel and develop great strength under these conditions, and continue to hold that strength, it can then be called a good cement. The small laboratory tests are no criterion of what may be expected in actual construction work. Within a few months tests of concrete being made from sand-cement and placed in the Arrowrock and Elephant Butte Dams will be available for publication. It is not thought worth while at this time to publish results so far obtained as they do not yet reach the three-month period. It is sufficient to state that the sand-cement as actually manufactured is quite superior to any that was made in the laboratory and that the concrete is developing greater strength than the laboratory tests indicated, being amply strong for the great stresses that are to be put upon it.

Sand-cement has as its recommendations that it is cheaper than portland cement and develops as good strength. It is less liable to be acted upon by alkaline waters, is always sound and on account of its greater fineness gives a better appearance to concrete in which it is used.

But few instances have been noted in which sand-cement has shown any deterioration with time. Its increase in strength is gradual but steady. No retarder, such as plaster of paris, is necessary to control the set, as the puzzolanic action, which is much slower than the ordinary setting of portland cement, can be depended upon to act in this capacity.

It is to be hoped that the portland-cement manufacturers will interest themselves in this product and that if it proves its worth its manufacture may become more widespread. Cheaper cement would mean more cement sold, more cement houses and cement work done in the cities and country.

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Municipal Ownership and Operation of street railways in Detroit was approved at a municipal election on Apr. 7 together with proposals to increase the bonded indebtedness of the city and to place city employees under civil service rules. Completion of this municipal project is held up by court actions.

There is to be a board of three street railway commissioners to serve without salary and to be subject to removal at the will of the mayor. The board may purchase, lease or condemn all or any part of existing street-railway properties in the city and may operate for a distance of 10 miles from the city limit. To provide funds the Common Council is empowered to issue bonds to the amount of 2% of the assessed value of real and personal properties in the city on request of the street-railway board. Additional bonds may be secured by the properties and revenues of the street-railway system. The rate of fare to be charged is specified as sufficient to pay (1) operating and maintenance expenses, including paving and sprinkling between tracks, (2) taxes on physical property of the entire system as though privately owned, (3) fixed charges, (4) a sufficient per cent. to provide a sinking fund to pay the principal of the mortgage bonds and other per cents to provide a sinking fund to pay the principal of the general bonds.

Cracks in a Brass Switch-Rod—An investigation of cracks which a 1¼-in. brass switch-rod developed during service is reported in the "A. E. G. Journal" of May, 1913. Some of its essential parts are, in substance:

The brass rod in addition to a longitudinal crack showed a number of transverse cracks. It could be seen that the parts of the rod bounded by the cross cracks had expanded. This observation gave rise to the assumption that the outer skin of the brass rod had tried to expand, this expansion having been prevented by the inner core, so that strains were set up which would finally lead to cracks under external stress. The chemical analysis of the rod gave the following results: Cu, 58.48%; Zn, 40.26%; Pb, 1.23%; Fe, 0.03%. Experience with similar qualities of brass containing considerably more lead than the rod in question had shown that the lead did not give rise to cracks. Microscopic samples were taken from different points of the rod and etched, with the result that the inner structure of the rod was found to differ appreciably from the structure of the outer layers, the interior being coarser. It was concluded that the cracks were not due to faulty composition but to stresses in the material caused by cold drawing. The recommendation is made that cracking of drawn-brass rods may be avoided in practice by heating the material after each drawing, and by minimizing the reduction per pass. Limiting the heating to 300° C. is recommended.

Electric Power for Quarries, Gravel Plants and Contract Work*

Stone Quarries

Stone quarries form a most desirable load for central-station service. They are usually located not far from some small town; or, rather, a small town will usually spring up adjacent to a stone quarry of any considerable size. In all except the very largest quarries, the load is strictly a summer load, the quarry shutting down as soon as the ground is frozen. The machines to be driven are of a nature extremely adaptable to motor drive, and the industry presents no absolute demands for steam in the process of manufacture.

A requisite of prime importance in quarry practice is the flexibility of the source of power with motor drive. The frequently changing heads to which drainage pumps are subjected, the continual shifting in location of such pumps, the changing lengths and grades of hauls and inclines, the remodeling and extension of compressed-air pipe lines, the varying grades of stone encountered, and numerous other contingencies, make it often necessary to call upon the overload capacities of motors and machines.

In the quarry-proper the main operations consist of drilling, blasting, hauling and (where there is seepage of water into the quarry) pumping.

DRILLING—The drilling of the rock preparatory to blasting in various quarries is done by four general types of drills: (1) Compressed-air tripod drills, making a 2- to 3-in. hole; (2) well drills making a 4- to 6-in. hole; (3) electric-air "pulsator" tripod drills for the same class of work as the compressed-air tripod drill; and (4) hand drills for placing "pot shots" to break large-size stones.

A compressed-air tripod drill requires about 150 cu.ft. of air at 90 lb. pressure at the drill for best operation. An electric-air "pulsator" drill has a small, specially constructed air-compressor as part of its equipment. The air-compressor is driven by a 7.5-hp. motor, the motor being started and stopped as the drill is operated or shut down. With both compresed-air and "pulsator" tripod drills the maximum efficient depth of hole is about 22 ft. and numerous changes in drill size are required as the hole deepens. The electric-air drill has a drilling capacity 25% greater than a similar compressed-air drill and the power consumption of the electric-air drill is less than 25% that required by the compressed-air drill.

The electric-air drill has not yet been very generally adopted in quarry practice because it is necessary to have the small motor-driven compressor located within 9 ft. of the drill proper, and quarrymen are not fully educated to the advantages to be obtained by the use of the electric-air outfit.

Well-type drills are used in quarries where the working face is 40 to 100 ft. high. A series of 5- to 6-in. holes are drilled the full depth of face and 25,000 to 50,000 yd. of rock loosened at one blast. Well drills are equipped with 10- or 15-hp. variable-speed motors and have become very popular; their use not only improves quarrying conditions, but reduces the cost of power, labor and dynamite for drilling and blasting.

There will be needed around each quarry from two to six hand drills for drilling small holes for "pot shots." These drills require about 50 cu.ft. of air each and one or more of them will be in pretty steady use.

HAULAGE—The manner in which rock cars are transported from quarry to crusher plant depends upon local conditions. If the quarry is deep, a system of inclines and drum hoists is employed; electric tramways are in use at numerous quarries and have been successful on grades as great as 6%. There are two general types of motor-driven hoists for this work; one type uses a motor which runs continuously and the hoisting drums are controlled by friction clutches and band brakes; the other type has a variable-speed motor, direct-geared to the drum and the motor is started, stopped or reversed as desired. Either type of hoist is controlled by a man placed at the top of the incline, and the cars are usually self-dumping.

CRUSHERS—The gyratory crusher is the most popular; roll crushers are used to some extent, and jaw crushers are used considerably in plants having a capacity of less than 250 cu.yd. per day. Rolls and disk crushers are used to a great extent for crushing smaller sizes of rock. From discharge openings at the base of the main crusher the rock drops into an elevator which raises it to a rotary sizing screen.

A combination of individual and group drive will be found most advantageous in crusher plants and the use of 440-volt motors will generally prove best. Crushers should be driven by slip-ring motors. If a crusher is shut down when it is full of rock it is often a troublesome job to clear it of all rock before starting up again. This is especially true if the crusher is driven by a squirrel-cage motor. If a slip-ring motor is used and the crusher belt is backed up a few feet by hand, the motor will often be able to start the crusher without its being necessary to clean out the rock. Dust-proof bearings should be used on all stone plant motors and it will usually pay to install all wiring in conduit. The use of slip-ring motors is to be recommended for air-compressor drive on account of the heavy starting load.

PUMPING—On account of there being at times considerable grit in the water pumped, the use of centrifugal pumps is usually best on this service. The use of the direct-connected centrifugal pump makes a pumping unit easy to move from point to point. The use of automatically controlled, slip-ring motors will be found to work out most satisfactorily for this service.

Sand and Gravel Plants

Plants having power-driven machines vary in size from one requiring 10 hp. to drive a short belt conveyor and dry screen, to plants requiring 300 or 400 hp. The power demand is more steady during time of operation than either stone quarries or brick plants, and as no steam is required (except in special cases for manufacturing purposes) central-station energy can be used to great advantage. The sand and gravel season closes as soon as the ground is frozen and plants shut down at dark, so that the load is strictly "off peak." Some attempt has been made to do dry screening in winter but with small success.

Motor drive and central-station service have been thoroughly tried out in this industry. The flexibility of motor drive is of great value here. Putting individual motors on distant pumps and outlying belts dispenses with the operating troubles from long steam lines and long rope drives. On account of pumps being often of considerable size and located several hundred feet from the screening plant, the use of 440-volt motors will in general be found desirable.

Plants getting sand from river or lake bottoms by means of "sand-sucker" pumps, make equally desirable load for the central station. In plants of any considerable size (400 cu.yd. and over) the sand and gravel are loaded from the bank into small cars by a steam or electric shovel. Central stations should be cautious in recommending the use of or of taking on electric shovels in this class of work, as their load is of a very fluctuating nature and may cause considerable disturbance on transmission lines. The local lines to such shovels are also of a very temporary nature and are subject to short circuits.

The shovel often works several hundred or even thousand feet from the main gravel plant, and the cars loaded by the shovel are hauled to and over the hopper at the loading end of the main conveyor belt by means of a small steam locomotive, electric locomotive or stationary car puller. The motors on such car pullers, or hoists, vary between 15 and 75 hp., depending on the size of cars, length of run, speed of cars and rise of incline.

From the hopper the sand and gravel are usually carried to the top of the screening and crushing plant by a long endless belt-conveyor.

Excavating Plants

In districts where irrigation or drainage projects require the digging of large canals there is another source of revenue from rural business. Contractors on this class of work are usually in a hurry and want equipment which will be subject to the least delay required by repairs.

Where the ground is not too hard and dirt taken out of the canal is to be deposited along the bank, the drag-line excavator has been found to be a highly efficient machine. We have stated above that care should be exercised in taking on electric-shovel loads because of their extreme fluctuations. This criticism does not hold for excavators of the drag-line type or having clam-shell buckets, which dig down into their load. The drag-line type of excavator has not these severe fluctuations and is a highly desirable load for a cross-country transmission line.

In this type of machine the large drag-line motor usually runs continuously and the lines are controlled by means of friction clutches on the winding drums; the motor which turns the excavator to swing the boom running when it is desired to swing. The friction clutches require considerable pressure and are operated by compressed-air, requiring a small motor-driven compressor. Current is carried into the

*From the report of the Committee on Electricity in Rural Districts, presented at the annual meeting of the National Electric Light Association, at Chicago, June 3-6.

excavator cab through collector rings, some 6 ft. diameter, under the cab floor and surrounding the king-pin.

Two electric drag-line excavators are to dig an eight-mile section of a canal, which will require about three years. Each excavator has a 112-hp., 440-volt motor on the drag line, 50-hp. motor for turning and 5-hp. for driving the air compressor. Besides these there are on the job about 100 hp. on drainage pumps and 10 hp. driving the machine shop, making a total of about 450 hp. The contractors have under consideration a complete electrical cooking equipment for the camp boarding house.

The central station furnishing power for this project extended its 33,000-volt transmission line about 4½ miles to the middle of the canal section, where a substation was installed stepping down to 2300 volts. Two 2300-volt, 3-phase feeders are taken out of the substation and the pole lines are extended each way as the excavators move forward. The 2300-volt feeders terminate on poles on specially built wagons for transformers stepping down from 2300 volts to 440 volts. From the transformer wagons about 150 ft. of 440-volt cables, lying on the ground, carry the current to the excavator collector rings.

Lighting current in the excavator cabs is obtained by transformers located in the cabs, stepping down from 440 to 110 volts. There are three 100-kw. transformers in the 33,000-volt substation and three 50-kw. transformers are put on each transformer wagon. Other transformers stepping down from 2300 to 440 and 110 volts are scattered around the job as desired by the contractor.

The contractor guaranteed the central-station company enough income to warrant the 33,000-volt line extension (besides this there was incidental farm business along the way). He erected a sheet-iron building for the 33,000-volt transformers and made his own line extensions at 2300 volts. The company furnishes all transformers and the current is measured at 2300 volts.

This installation has not been in operation long enough to furnish any accurate data on the cost per cu.yd., but during April, 1913, the power consumption was 48,480 kw.hr., the maximum demand on a 30-minute basis 156 kw. and the power bill $929.09.

Sanitary Precautions to Protect the Watershed of a City Water-Supply During the Construction of an Electric Railway*

The following regulations were prepared by the Board of Water Commissioners of Springfield, Mass., as a part of the contract by which the Berkshire Street Ry. acquires a right-of-way through the watershed of the Little River water supply. These regulations have been approved by the Massachusetts State Board of Health, subject to amendment after further examination.

SECTION 1. The Berkshire Street Ry. Co., its contractors and employees, shall prevent nuisances in and about all camps and works; shall protect water courses, reservoirs, and all sources of water supply from pollution, contamination, or interference, and safeguard the public health as may be directed from time to time by the constituted authorities of the State and City. Said Company shall summarily dismiss, or cause to be dismissed, and not again engage except with the written consent of the engineer, any employee who violates this section.

SECTION 2. The Board of Water Commissioners of the City of Springfield shall have the right, in order to determine whether the requirements as to sanitary matters are being complied with, to enter and inspect any camp or building or any part of the works, and to cause any employee to be examined physically or medically or treated; also to inspect the drinking water and food supplied to the employees. The sanitary precautions, the care of the employees, the camps and all territory occupied by the Company or its contractors, shall at all times be satisfactory to the engineer or other authorized representative of the Water Department. Said Company shall promptly and fully, and in every particular, comply with all orders and regulations in regard to these matters, including all sanitary and medical rules and regulations which may have been or may be promulgated from time to time. And to this end and to properly preserve the peace, the Board of Water Commissioners shall have the right of access to the camps and quarters of the Company or its contractors.

SECTION 3. No camps shall be located on the watershed of the City of Springfield, if suitable sites are existent off the watershed which could be made available for such camps, but camps placed outside the watershed shall not be located on the watershed of any other water supply. Any camp located on the watershed can only be so located after its approval by the engineer of the Board of Water Commissioners of the City of Springfield, the camps shall, if ordered, be inclosed by barbed wire or other approved fences not less than 10 ft. high, with not more than two entrances. Each camp and grounds surrounding it in all directions shall be thoroughly illuminated by high power acceptable lights. This illumination shall be maintained from sundown to sunrise every night during the occupation of the camp, unless otherwise ordered. Employees shall, so far as practicable, be required to remain within camp when not at work.

SECTION 4. Buildings for the sanitary necessities of all persons employed on the work, beginning with the first men employed to build camps or for other preliminary operations, shall be constructed and maintained by the Company, or its representatives, in the number, manner, and places ordered. All persons connected with the works shall be obliged to use these conveniences under penalty of discharge. Unless otherwise directed, the sanitaries shall be provided with water-tight removable receptacles of suitable capacity. These receptacles, if used, shall not be allowed to overflow, but shall be removed without spilling, at required intervals, their contents at once treated as directed, and then promptly taken to a designated place outside the watershed, and there disposed of as ordered. In case camps are located on the watershed, incinerators of satisfactory design shall be provided, which shall satisfactorily consume all night soil and other camp refuse. Said Company shall provide a sufficient number of acceptable attendants to keep all sanitaries in satisfactory condition and compel employees to use them.

SECTION 5. Said Company shall retain the services of acceptable qualified medical practitioners, to the number ordered, who shall have the care of the employees of the Company or its contractors, shall inspect their dwellings, the stables, and the sanitaries as often as required, and shall supply medical attendance and medicines to the employees whenever needed. Whenever practicable, an employee having a communicable disease shall be removed, when and as directed, to a hospital outside the watershed. The medical supervision of the Company over its employees shall extend to the physical and medical examination of all applicants for employment, in order to prevent persons having communicable diseases from becoming connected with the work, and the Company or its contractors shall employ only persons shown by such examination to be free from communicable diseases. Whenever, in the opinion of the engineer, it is necessary for the protection of the public health or the health of the employees, the Company shall remove or cause to be removed any employee from the work to a hospital, or shall remove permanently from the work or any camp any employee whose presence is believed to endanger the health of other persons.

SECTION 6. Once each week, or more frequently if required, the Company shall give the engineer, in such detail as may be prescribed from time to time, a written report signed by the physician in regular attendance, setting forth clearly the health conditions of the camp or camps and of the employees.

SECTION 7. The water furnished by the Company shall include a sufficient supply of drinking water of acceptable quality for all its employees, to be obtained from approved sources. If any water supply for domestic uses should become contaminated, the Company shall promptly provide a new supply from an approved source and abandon the contaminated supply, or shall provide works for purifying the contaminated water when and as ordered.

SECTION 8. All wash water from kitchens, laundries, and other places, and all drainage from stables, shall be conveyed by satisfactory means to places directed, where such drainage shall be treated by the means ordered so as to yield an acceptably innocuous effluent.

SECTION 9. Drainage from camps and shelters and from other places yielding water unfit for direct discharge into a reservoir or tributary thereof shall be conducted in tight drains or other approved conveyors to filters, septic tanks, or other disposal plants of approved construction, at places designated, and treated as directed to produce an acceptable effluent. Such effluent shall be discharged only in the manner and at the place or places directed. All arrangements for drainage shall be sufficient to provide for all rain water falling within the camp, so that there will be no overflow from camps which shall at any time reach the water course of the watershed without purification.

SECTION 10. Garbage, both liquid and solid, shall be promptly and satisfactorily removed from the buildings and immediately placed in approved tight receptacles of sufficient capacity for about one day's ordinary production. At least once in every twenty-four hours all such garbage shall be incinerated or otherwise thoroughly and satisfactorily disposed of in an approved manner.

SECTION 11. Shelters and other conveniences for the workmen within the watershed shall be provided with sanitaries for the use of all workmen, and other sanitaries shall also be provided near all points of work. The use of these must be insisted on under penalty of discharge, and sufficient inspectors must be provided to see that sufficient sanitaries are provided and that all workmen use them at all times on the watershed. All night soil thus collected shall be in tight receptacles, and shall be disposed of at times and in manners heretofore provided or specified by the engineer of the Water Department.

SECTION 12. The Company shall build such disposal plants, sewers, drains, and other structures, and shall do such other work, not herein particularly specified, as may be ordered for carrying out the intent of these regulations.

*From the Annual Report of the Water Commissioners of Springfield, Mass., 1912.

A Commission to Study the Administrative Procedure of Municipalities and to make recommendations on the subject was authorized by the New Jersey State Legislature of 1913.

Stream Flow Gagings under Anchor Ice Conditions

By Chester Wason Smith*

As it is often highly desirable to determine correctly the minimum flow of a stream, and as on many streams the minimum flow occurs in winter when measurements are, or may be, largely affected by ice conditions, it is thought that the measurements herein described may be of some interest.†

The stream illustrated is a northern stream, the winter flow of which fluctuates with the temperature, and it has a watershed of about 10,500 sq.mi. above the point of measurement.

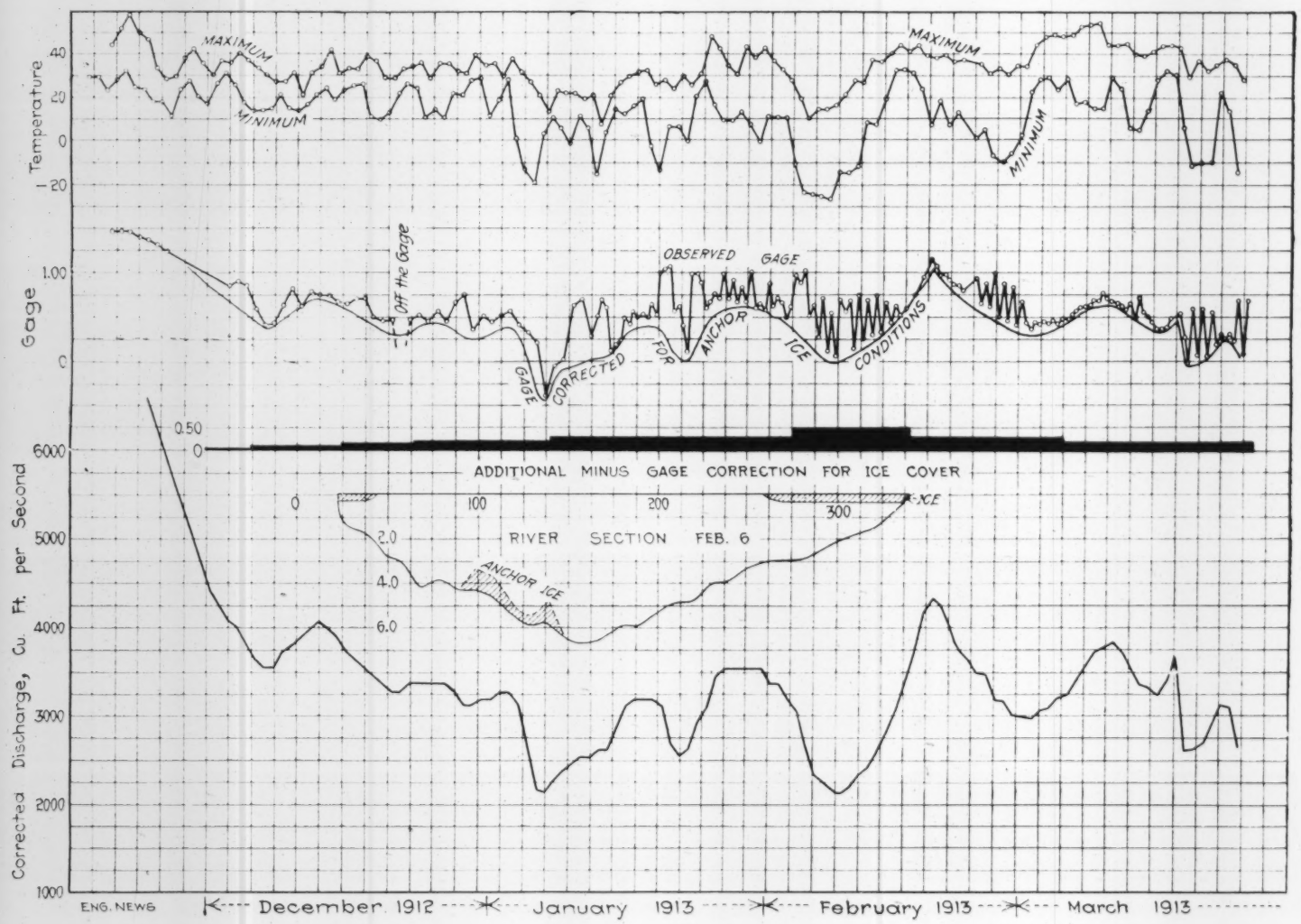
Previous figures as to the flow had been based upon daily gage heights and a fairly well determined open-water rating curve, together with a general but rather casual consideration of temperatures. There were some indications that the minimum flow might be less than had been supposed; so beginning Jan. 12, the gage was observed twice daily, and from Feb. 3 to Apr. 1 an experienced hydrographer was kept at the station making daily current meter measurements and such other observations as might assist in a determination of the true flow.

The meter measurements were made from a boat running on a cable stretched across the river. About a thousand feet below the station was a riffle or rapids in the river, also another about 1½ miles above the station. The gage was at the station, though another one was later established on the riffle below.

Above the upper riffle was slack water, with the river entirely frozen over for about ten miles. The river is straight for some distance above and below the station, has a gravel bed with few boulders, and is shown in section on the accompanying diagram.

The diagram shows the daily maximum and minimum temperatures, the daily (and after Jan. 12 the a.m. and p.m.) observed gage readings. The derivation of the corrected gage height and finally estimated discharge curves will be explained.

That the flow was dependent on the temperature and fluctuated with it was to have been expected, but the very sensitive and immediate agreement is interesting to follow. Beginning with the cold weather Nov. 20 to Dec. 1, when the smaller tributaries froze up, the flow



Stream Flow Gagings in Winter, Showing Effect of Temperature and Anchor-Ice

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†Earlier articles on the winter measurement of stream flow, but dealing generally with under-ice flows, have appeared in our columns as follows:

"Records of Flow at Current Meter Gaging Stations When the Streams are Subject to Ice." By F. H. Tillinghast, May 11, 1905.

"Determination of Stream Flow During the Frozen Season." By C. Robert Adams, Feb. 2, 1911.

"Gaging Minnesota Streams in Winter." By W. G. Hoyt, Sept. 12, 1912, p. 409.

"Methods of Estimating Stream Flow When Streams are Frozen." By W. G. Hoyt, Apr. 10, 1913.

A monograph on "Determination of Stream Flow During the Frozen Season," by H. K. Barrows and Robert E. Horton, was published in 1907 by the U. S. Geological Survey, as Water Supply Paper No. 187.

is alternately checked and released precisely as the temperature varies, and leads to the conjecture that previous winter flows could be analyzed almost from a study of temperature conditions alone. A suspicion that the true flow of such a stream could not fluctuate as rapidly as the gage heights led to the taking of gage readings twice daily, when the fluctuations at once showed up more violent still.

The fluctuations were caused by anchor and slush ice lodging on the head of the riffle below and acting as a dam to back up the water until the pressure became enough to dislodge it, when, of course, the level of the water fell until it represented the normal flow of the river, or until ice again began to lodge. Anchor ice also formed or collected at times on the river bottom at the gaging station and had something of the same effect on the water elevation.

In general it seemed to be that the anchor ice formed and lodged during the night and went out during the day, though of course this procedure was modified by temperature conditions, and seemingly to some extent also by whether it was a sunny or a cloudy day. Depending on the temperature, anchor ice would form in varying quantities, also floating slush or cakes would assist in forming the jam; undoubtedly, the two daily readings did not catch all of the maximum and minimum fluctuations of the gage.

The effective gage height was assumed as a line drawn practically through the daily minimum readings, to which was applied a further correction, as shown on the chart, to allow for the more stable condition of surface solid ice with consequent reduction of section and increase of friction. The amount of this final correction was a matter of the judgment of the hydrographer, and varied with the extent and thickness of the surface ice.

The final gage heights thus obtained were considered as indicating a flow equal to the same heights on the open-water rating curve; which curve, not having been previously determined for such low flows, was extended downward parallel to the general trend of the best discharge measurements under ice conditions.

It will be seen at once that not only the gage height, but any measured discharge, might vary widely from the true normal 24-hour flow of the river; disregarding for the moment the effect of the surface solid ice. For instance, assume that the actual flow on a certain day (as on Feb. 1, see diagram) was 3360 sec.-ft. and that the control point at the head of the riffle below was free from anchor or floating ice, then the gage would read 0.50 and a meter measurement would show that relation between gage height and discharge.

Second, assume the same flow (3360 sec.-ft.) but that anchor and floating ice was collecting on the control point so that the gage climbed up to 1.00, then a meter measurement taken during the period while the gage was going say from 0.70 to 1.00 would show that for average gage of 0.85 the quantity of water actually passing the gaging station would be 3360 sec.-ft. *minus* the amount being *put into storage* by raising the 1½ miles of river, between the station and the riffle upstream, from 0.70 to 1.

Again assume, with the actual flow still 3360 sec.-ft., that at the stage of 1.00 the jam is pushed out and another meter measurement is taken while the river is falling from 1.00 to 0.70, then the actual quantity passing the gaging station would be 3360 sec.-ft. *plus* the same above mentioned amount passing *out from storage*.

Under such conditions a river becomes a series of alternately forming and disappearing reservoirs, which might (depending on the duration of the pulsation) adversely affect a project which had storage only for its daily peak.

It will be readily seen that it was necessary to carefully watch the gage and differentiate between the fluctuations caused by collections of ice on the control, and those caused by a period of milder weather with consequent increase in actual flow; also that for practical purposes any measurement at time of fictitious gage height should be eliminated.

Under the conditions obtaining along the river above the gaging station it did not seem probable that anchor and floating ice could act to reduce the gage height *below* the true normal; in other words, the fluctuations were all upon one side of the truth. This was because the water emerging from under ten miles of surface ice, carried no anchor ice and none formed in the short distance to the first riffle. Coming down over the first riffle, and in its passage by the gaging station to the second riffle, the water got enough colder so that anchor ice formed. If the ten miles of river above the upper riffle had not been protected by ice cover, anchor ice would undoubtedly have formed and created similar jams on the upper riffle, with longer periods between fluctuations owing to the much larger storage for same change in height. In this case the gage in the pool below would have shown fluctuations considerably below the normal, as to a certain extent the pool would have drained down while water was being stored above.

Anchor ice may accumulate somewhat on the rough river bed along a riffle, enough to have some effect on a gage placed on the riffle, but a jam proper would not form because, owing to the relatively steep grade and swift current, the water would almost momentarily back up enough to push the jam along. The real jams would form at the head of the riffle. A gage on the riffle, while not subject to such wide fluctuations as one in the pool, still might not be any better indication of the true actual flow; for while subject perhaps to but slight fictitious raises, it might be depressed considerably below the normal from a jam above. Then the jam might form upon only a portion of the width of the river; it might form upon either side or in the middle and while backing up water in the pool, divert the water actually passing, to one side or the other for some distance below.

In fact it would be quite possible to observe all manner of apparent inconsistencies in the simultaneous readings of several gages placed within quite short distances of each other.

In making a determination of the winter flow of such a stream it is necessary to carefully study conditions for some distance up and down stream from the gaging station. Select a gaging station that will not be affected by jams of anchor or floating ice, or if that is impossible, aim to get one such that the fictitious fluctuations may be readily recognized both in direction and amount. Depending on the character of the stream and the station it might be highly desirable that a recording gage be established so as to show all the fluctuations.

A New Design for Water-Works Intake Cribs

By W. D. Barber*

SYNOPSIS—The water-supply intakes at cities taking their supply from the Great Lakes are troubled more or less by ice and floating impurities, the handling of which adds to the cost of operation. The article given herewith outlines the features of the design of the present intake cribs, and the difficulties encountered in maintaining a uniform supply of good water from them. It describes also a new design of crib, combined with submerged intakes, which has been proposed for use in connection with the two new water intakes for the city of Chicago.

A number of towns and cities on the Great Lakes are using these immense reservoirs as the source of their water supply. The method employed to obtain this water is to run pipes or tunnels out to deep water and admit the water through ports in cribs or sunken intakes, but many difficulties are encountered in the operation of such cribs. The purpose of this article is to outline the construction of intakes of this kind and to describe a new design of crib which it is thought will eliminate the present difficulties. The aim is to reduce the cost of construction and operation, and to secure an abundant supply of pure water. The largest and most important cities that take their water-supply in this way are Chicago, Cleveland, Buffalo, Toronto, Milwaukee, Gary and Erie. Of these cities Chicago has spent by far the greatest amount of money along this line, and has built six of the eight large cribs now in use. Cleveland and Buffalo have the others. The characteristics of all these are shown in the accompanying table.† The other cities mentioned take their supply from submerged intakes or some modified form of these.

Present Design of Lake Intake Cribs

The crib is practically a hollow cylindrical or polygonal structure sunk to a firm foundation in the bed of the lake and rising above the water-surface. Horizontal ports in the walls admit water to the central space or well, in the center of which is a vertical intake pipe or cylinder forming an extension of the shaft from the tunnel which carries the water to the city. In the sides of this pipe are intake or controlling gates, but in one case the top of this pipe is below water level. The typical construction is shown in Fig. 1, which represents the Carter H. Harrison crib.

The eight large cribs vary in capacity (based on an average velocity of flow in the supply tunnels of 3 ft. per sec.) from 54,000,000 to 300,000,000 gal. per 24 hours. The smallest is the Lake View crib, and the largest is the Edward F. Dunne crib (1911), both at Chicago. These cribs are placed 6500 to 22,000 ft. from shore, in water 26 to 50 ft. deep. The ports are rectangular, ranging from 4x4 to 6x8 ft. in size, and placed 6 to 25 ft. below the surface. Anchor ice forms at certain periods in the crib ports, and in the gates around the intake shaft, at the center of the crib. At certain periods also fish are quite troublesome and screens have been placed over the shaft gates to exclude fish and dirt.

At Chicago, long, hard storms from the east and northeast disturb the water along the shore and the muddy water is carried by the undertow to points beyond the cribs, thus placing them within the zone of muddy water,

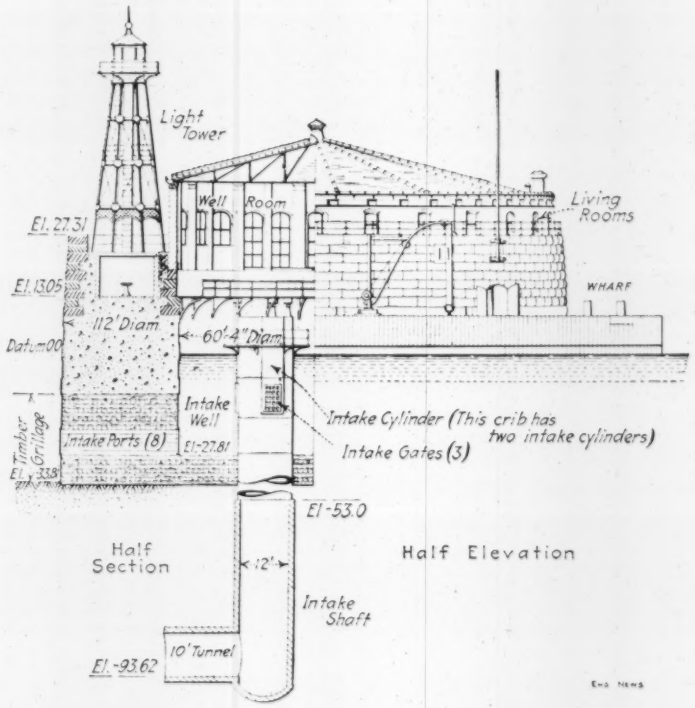

Fig. 1. Typical Example of Water-Works Intake Crib; the Carter H. Harrison Crib at Chicago
(This crib has two intake cylinders.)

causing at such periods the whole water-supply of the city to become more or less objectionable for use. Other sources of pollution are from sewage and the dumping of refuse from scows in the path of currents that carry these impurities by the cribs so that they may be drawn into the ports.

The general shape of the present cribs is either circular or polygonal in plan. They are usually built of timber cribbing for 15 to 30 ft. from the bottom, and extended to the crib floor (some 13 ft. above the lake surface) by means of steel shells or timber walls with the intervening space filled with stone or concrete. The Buffalo crib is built of steel shells from the bottom up. In size, they vary from about 65 to 114 ft. outside diameter, while the diameter of the interior (or the intake well) varies from 30 to 70 ft. The wall of the crib is 18 to 30 ft. thick, and in the best cribs is composed of concrete filling between the inner and outer steel shells.

Defects of Present Crib Design

The defective features of cribs of the present type may be listed as follows:

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†The various water-intake cribs and tunnels on the Great Lakes have been described fully in "Engineering News," and we give the following references for the information of our readers.—Editor.

"The Chicago Intake Tunnels and Cribs"; Oct. 18 and Nov. 8, 1900.

"The C. H. Harrison Crib and Intake Tunnel (Chicago)"; Aug. 31, 1899.

"The Southwest Intake Tunnel (Chicago)"; Nov. 14, 1907, and June 17, 1909.

"The Intake Tunnel and Crib at Cleveland, Ohio"; Aug. 11, 1898.

"The Intake and Crib at Buffalo, N. Y."; Feb. 9, 1911.

WATER-WORKS INTAKE CRIBS ON THE GREAT LAKES

	Chicago			Cleveland	Buffalo
1. Name of crib	Four-Mile	Hyde Park	E. F. Dunne	.....	.....
2. Location	Harrison St.	68th St.	59th St.	4 miles	Porter Ave.
3. Distance from shore	20,500 ft.	10,500 ft.	11,300 ft.	49 ft.	6500 ft.
4. Depth of water	40 ft.	32 ft.	32 ft.	Circular	30 ft.
5. Crib, shape	Circular	6-sided	24-sided	100 ft.	Circular
6. Crib, diameter	114 ft.	84 ft. 6 in.	112 ft.	Circular	110 ft.
7. Intake well, shape	Circular	6-sided	Circular	50 ft.	Circular
8. Intake well, diameter	70 ft.	30 ft. 6 in.	60 ft.	25 ft.	70 ft.
9. Thickness of side	22 ft.	27 ft.	26 ft.	(12) 7½x6 ft.	20 ft.
10. Ports in crib	(6) 5x5 ft.	(6) 5.583.5 ft.	(8) 7x7 ft.	519 sq.ft.	(12) 6x6 in.
11. Area of ports	150 sq.ft.	115.5 sq.ft.	392 sq.ft.	6 at 18 and 6 at 24 ft. from bottom	432 sq.ft.
12. Bottom of port below water	30 ft.	30 ft.	25.3 ft.		14 ft.
13. Gates in intake cylinder	(3) 4½x4½ ft.	(3) 4x5 ft.	(12), 6 each shaft 5x6½ ft.	Intake open*	(4) 5x6 ft.
14. Area of gates, sq.ft.	60.75 sq.ft.	60 sq.ft.	390 sq.ft.	95 sq.ft.	120 sq.ft.
15. Gates, depth below water	11 ft.	6 ft.	3 each shaft 21 ft.	.....	11 ft.
16. Intake shaft, diameter	10 ft.	9 ft.	3 each shaft 11½ ft.	11 ft.	13 ft.
17. Intake tunnel, invert below water level	96.5 ft.	64 ft.	(2) 12 ft. 3 in.	110 ft.	50.7 ft.
18. Intake tunnel, diameter	8 ft. (forking to two 6-ft.)	7 ft.	153 ft. Horseshoe; 14 ft., equiv.	9 ft.	12x13; vert. sides, segment roof
19. Intake tunnel, area of section	50.27 sq.ft.	38.48 sq.ft.	154 sq.ft.	63.6 sq.ft.	128.66 sq.ft.
20. Flow capacity of tunnel (at 2 ft. per sec.); mil.gal. per 24 hr.	65.1	49.8	200	82.4	166.75
21. Date of crib (completed)	1890–94	Rebuilt 1896	1906–1911	1903	1908–10
22. Cost of crib and superstructure	$473,000	$137,600	$425,000	.....	.....
23. Cost of operating crib, 1911					
24. Ratio of area of crib ports to shaft gates	1 : 0.40	1 : 0.52	1 : 1	1 : 0.183	1 : 0.277
25. Ratio of area of crib ports to tunnel	1 : 0.303	1 : 0.333	1 : 0.398	1 : 0.123	1 : 0.295

	Lake View	C. H. Harrison	Two-Mile
1. Name of crib	Montrose Ave	North Ave.	Division St.
2. Location	10,000 ft.	14,000 ft.	10,000 ft.
3. Distance from shore	26 ft.	34 ft.	33 ft.
4. Depth of water	12-sided	Circular	5-sided
5. Crib, shape	72 ft. 6 in.	112 ft.	58-ft. sides
6. Crib, diameter	6-sided	Circular	5-sided
7. Intake well, shape	21 ft. 6 in.	60 ft. 4 in.	22-ft. sides
8. Intake well, diameter	25 ft. 6 in.	26 ft. 0 in.	25 ft.
9. Thickness of side	(4) 4x4½ ft.	(6) 5.585.6 ft.	(3) 5x4 ft.
10. Ports in crib	72 sq.ft.	180 sq.ft.	60 sq.ft.
11. Area of ports			
12. Bottom of port below water	22 ft.	26.5 ft.	30, 19 & 8 ft.
13. Gates in intake cylinder	(3) 4x4 ft.	(3) 6x4½ ft.	A (2) 4.5x3.6 ft. B (3) 4.5x4.5 ft. C (3) 4.5x4.5 ft.
14. Area of gates, sq.ft.	48 sq.ft.	81 sq.ft.	84.75+60.75
15. Gates, depth below water	22 ft.	20 ft.	A, 2 ft.; B, 18 ft.; C, 15 ft.
16. Intake shaft, diameter	10 ft.	11 ft.	A, 9 ft.; B, 8 ft.; C, 10 ft.
17. Intake tunnel, invert below water level	63.3 ft.	93.5 ft.	A, 62 ft.; B, 61 ft.; C, 63 ft.
18. Intake tunnel, diameter	6 ft.	10 ft.	A, 5; B & C, 7
19. Intake tunnel, area of section	28.27 sq.ft.	78.54 sq.ft.	58.11+38.48
20. Flow capacity of tunnel (at 2 ft. per sec.); mil.gal. per 24 hr.	36.6	101.8	3 tunnels, 125.2
21. Date of crib (completed)	1896	1896–99	1867 (enlarged 1895)
22. Cost of crib and superstructure	$167,200	$233,000	$117,500
23. Cost of operating crib, 1911			
24. Ratio of area of crib ports to shaft gates	1 : 0.666	1 : 0.45	1 : 1.45
25. Ratio of area of crib ports to tunnel	1 : 0.425	1 : 0.43	1 : 0.98.

*The top of intake cylinder is open at 21 ft. below water.

(1) The only means of controlling the water flow is by the gates on the intake pipe or shaft at the center of the well.

(2) The form of the crib ports permits the bulk of the water to be drawn directly from the surface of the lake, the draft being in the form of an inverted cone.

(3) Ice, dirt, fish, etc., may be drawn through the crib ports into the intake wall.

(4) The crib is an obstruction to floating ice, and during storms the ice is piled up on the windward side from 10 to 25 ft. above the surface and down to the bottom of the lake. This causes more or less obstruction to water entering the ports on the windward side. Fig. 2 shows an ice jam at the Two-Mile crib.

(5) All screens and other devices for keeping impurities from entering the supply tunnels are located in the well, just outside the gates of the intake shaft. There is no means of shutting off the flow of water into the well while cleaning the screens, and loose material removed from them usually falls back into the well.

(6) The intake well and well room in the center of the crib, from 60 to 90 ft. in diameter, with galleries, platforms, etc., is unnecessarily large. It greatly increases the cost of construction and operation, while adding nothing to the efficiency of the crib.

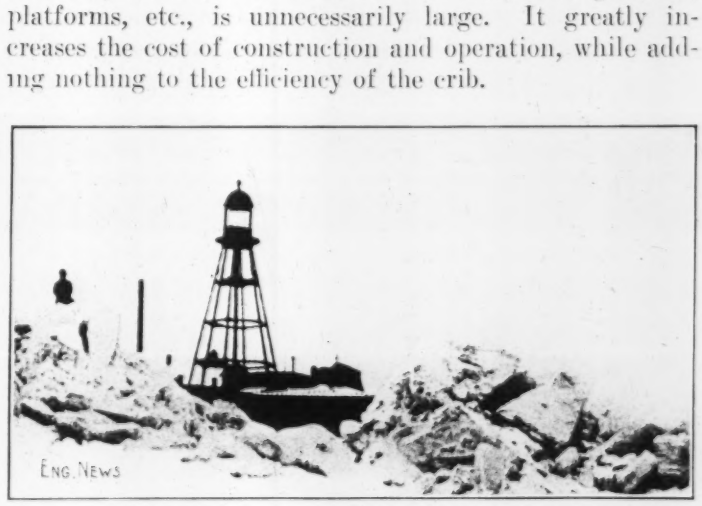

FIG. 2. AN ICE JAM AT THE TWO-MILE INTAKE CRIB; CHICAGO

(7) Owing to the defects in design, the operating force may vary from the normal force of one crib keeper and two assistants to some 25 to 30 men in winter, including enginemen and other mechanics.

RELATION OF WAVE ACTION TO PURITY OF WATER

Quality of the water being the first aim, the crib must be located in a pure-water zone and the supply taken from a depth where storm and surface conditions do not disturb the water drawn into the ports. The wave motion extends very little below a depth equal to the height of the wave, and this wave motion is mainly vertical. A wave moving toward the shore over water that is gradually getting shallow, when the depth equals the height of the wave, alters its shape, becomes more abrupt, and changes from an undulation to a wave of translation, thus causing the surface water to approach the shore. There is a resultant undertow or lower current back to deep water. The deeper the water the slower and more diffused becomes the current of the undertow. This undertow extends beyond the wave of translation. This is caused by the rise in the surface due to the wind.

From borings and soundings taken in Lake Michigan,

it is found that the sand covering the lake bottom extends to where the water is 22 to 24 ft. deep. This indicates that beyond this limit the undertow is too slow to carry heavy particles. From this point to a depth of 40 to 50 ft. simply a muddy condition of the water may prevail. It is safe to assume that the effect of wave action ceases at a depth of 25 to 30 ft., and the undertow or lower outward current at a depth of 40 to 45 ft. By placing the intake crib at this latter depth, with ports 10 or 15 ft. from the bottom and spread out so as to draw water from a large area, a supply of pure water would be practically assured.

Anchor Ice at Intakes

When the temperature of the water is at freezing point and the atmosphere is below freezing, the conditions are favorable for the formation of anchor ice. Even under these conditions ice is not formed readily in large bodies of water, where the surface is disturbed or kept in constant motion, unless the water first comes in contact with some substance whose temperature may readily be reduced to a point below freezing. When initial ice crystals have been formed under this condition, however, the ice formation becomes more or less rapid, depending upon the relative temperatures of the air and water. Where this water is in motion it will flow for long distances without any appreciable loss in its latent heat. The formation of ice also becomes more difficult of formation as the depth becomes greater.

If this cold water comes in contact with iron, stone, or other substances that may be reduced to a temperature below 32°, and the substance will permit of the adherence of ice to it, the troublesome anchor ice immediately begins to form. The velocity of the water will affect the rapidity of this ice formation, although the crib keepers say it has very little effect. A slow velocity where the water is flowing downward and the pressure increasing rapidly has a great tendency to result in forming anchor ice under the contact conditions noted.

Anchor ice will form in ports or intakes at times quite rapidly, even though the metal or substance to which this ice adheres is at great distances below the surface. This is evidenced at all deep ports and sunken intakes subjected to extremes of heat and cold. In a submerged orifice, when the water completely surrounds and covers the opening, the tendency is to draw the bulk of the water directly from the surface. This explains, in a measure, why anchor ice forms more rapidly as the velocity increases in the ports of existing cribs. The surface water or blanket covering to the deep water is being used as a supply, instead of the deep water of a denser volume. A simple experiment illustrating this is to watch the emptying of a wash basin or bath tub through a hole in the bottom. The circular motion, the column of air, and the suction directly over the opening, are quite evident.

The ice forms most rapidly and is most troublesome at about 1 to 6 a.m., when the temperature of the air is at its lowest point, but it may form quite rapidly during a cloudy day when the air is colder than the water. A blanket of ice on the surface of the water is a full protection against anchor ice. At one time, tugs were kept at work at the Chicago cribs to keep ice from forming in the ports, but this practice has been abandoned and better results are now obtained by allowing the surface ice to remain undisturbed.

In the cold weather of February and March the theory that the velocity of water in ports and the depth of port below the surface were the main checks to the formation of anchor ice, was given a rude shock, when at the Chicago crib having the largest and deepest ports (the Edward F. Dunne crib), these ports and the gates to the intake shafts were clogged to such an extent that the water in the crib well was lowered from 2 to 3 ft. when the pumps were drawing only 53,000,000 gal. per 24 hr. Had the pumping stations required the full capacity of 300,000,000 gal., it might have been practically impossible to keep the ports and even the intake shafts clear of ice. Taking this 53,000,000 gal. per 24 hr. and a zone extending 25 ft. beyond the ports as the source of supply, the water in this zone would be completely changed 22 times in 24 hr. in the 32 ft. of water at this place, or about 125 times if pumping full capacity. The temperature of the surface water thus drawn into the ports would give results practically the same as though the ports were near the surface. These conditions indicate that inlets should be not only deeply submerged, but also spread out over a large area of lake bottom, with special checks to prevent drawing in surface water.

New Intake Cribs and Tunnels at Chicago

The city of Chicago is preparing to build two new intake cribs about three miles from shore, one opposite 35th St. and the other opposite Wilson Ave., in water 38 ft. and 34 ft. deep. The intake tunnels will have a flow capacity of 400,000,000 and 300,000,000 gal., respectively, the former having a cross-sectional area equivalent to a diameter of 16.2 ft., with a shaft of the same diameter rising to the intake well of the crib. The velocity of flow in the tunnel to give this capacity is 3 ft. per sec.

At the 35th St. crib, we have 38 ft. of water in the lake with a medium hard clay bottom from 40 to 60 ft. below. The site is in water deep enough to place the intakes below the effect of wave action, but it is well within the zone of the undertow or muddy water during certain portions of the year. This crib will be some 16,000 ft. from shore, but it would have to be located from 8 to 10 miles out to secure the depth of 60 ft. necessary to eliminate this periodical condition, and the turbidity of the water may have no influence upon its quality. The size of a supply tunnel to furnish 400,000,000 gal. in 24 hr. at a velocity of 3 ft. per sec. will be equivalent to a circular tunnel of 16.2 ft. diameter. This tunnel will have to carry 53,330,000 cu.ft. of water per 24 hr. In water 38 ft. deep this will make a block of water 1340 ft. in diameter (deducting the 100 ft. crib diameter).

Considering that in the present design of crib and port no provision is made for keeping surface water from entering the well of crib (all water being drawn from the outside crib wall on a radius of from 50 to 57 ft.), it is easy to see why anchor ice will at certain times be a source of great annoyance, even though the velocity is only a foot or less per second in the total area of each port. If the body of water required to supply a crib as now constructed were considered to draw into ports from a reservoir extending 25 ft. beyond the port entrance, the water would have to be removed some 20 to 30 times per 24 hr. even though the flow was uniform from the sur-

face to the bottom of the lake. As the surface water furnishes the bulk of the supply, the rapidity of change is very much greater.

Operating Conditions at the Chicago Intake Cribs

The general particulars of the intake cribs are given in the accompanying table. The regular force for each of the Chicago cribs consists of a keeper at $1200 and two assistant keepers at $1000 each. As the 68th St. and Dunne cribs are connected, however, one force operates both of these. In winter, there are also from two to a dozen laborers to assist in clearing the ice: these are paid $2.50 per day and board (estimated at $1 each). The Two-Mile crib has three enginemen in winter, but the enginemen at the Lake View crib have been dispensed with by using a low-pressure steam system (10 lb.) which requires one-third less coal. The cost of operation (for 1911) given in the table, includes salaries, meals, supplies and repairs. The ice and water conditions at these cribs are as follows:

Lake View Crib: Anchor ice forms in the ports of the crib and in ports of the intake-shaft cylinder. When the current is slow, the ice does not form. The water is pure, but is roiled by storms.

Harrison Crib: Anchor ice forms in the intake-shaft cylinders, but not in the crib ports. During long-continued storms the water becomes roiled. There is no floating matter, as the prevailing winds carry it away.

Two-Mile Crib: The anchor ice has already formed at this crib in great quantities, and has required at times 30 or 35 men to keep the ports and intake gates free. A compressed-air system has been installed for blowing out the ice, and this has reduced the extra force. The air tank is 2x10 ft., carrying 60-lb. pressure, and a 4-in. pipe with 1¼-in. nozzle is thrust down into the center of the port. The ice dislodged flows into the well and is removed with wire dippers. The shaft intake ports and gates are then cleared in the same way. These have to be watched continuously.

Four-Mile Crib: This is further from shore and in deeper water than any of the other cribs. Anchor ice forms at times at the gates of the intake-shaft cylinder, due to increased velocity. The water gets roiled during long storms. A bill passed by Congress permits the dumping of scows some four miles west of the crib, and the wind brings the floating and semi-floating refuse to the crib, where it enters the ports and clogs the screens.

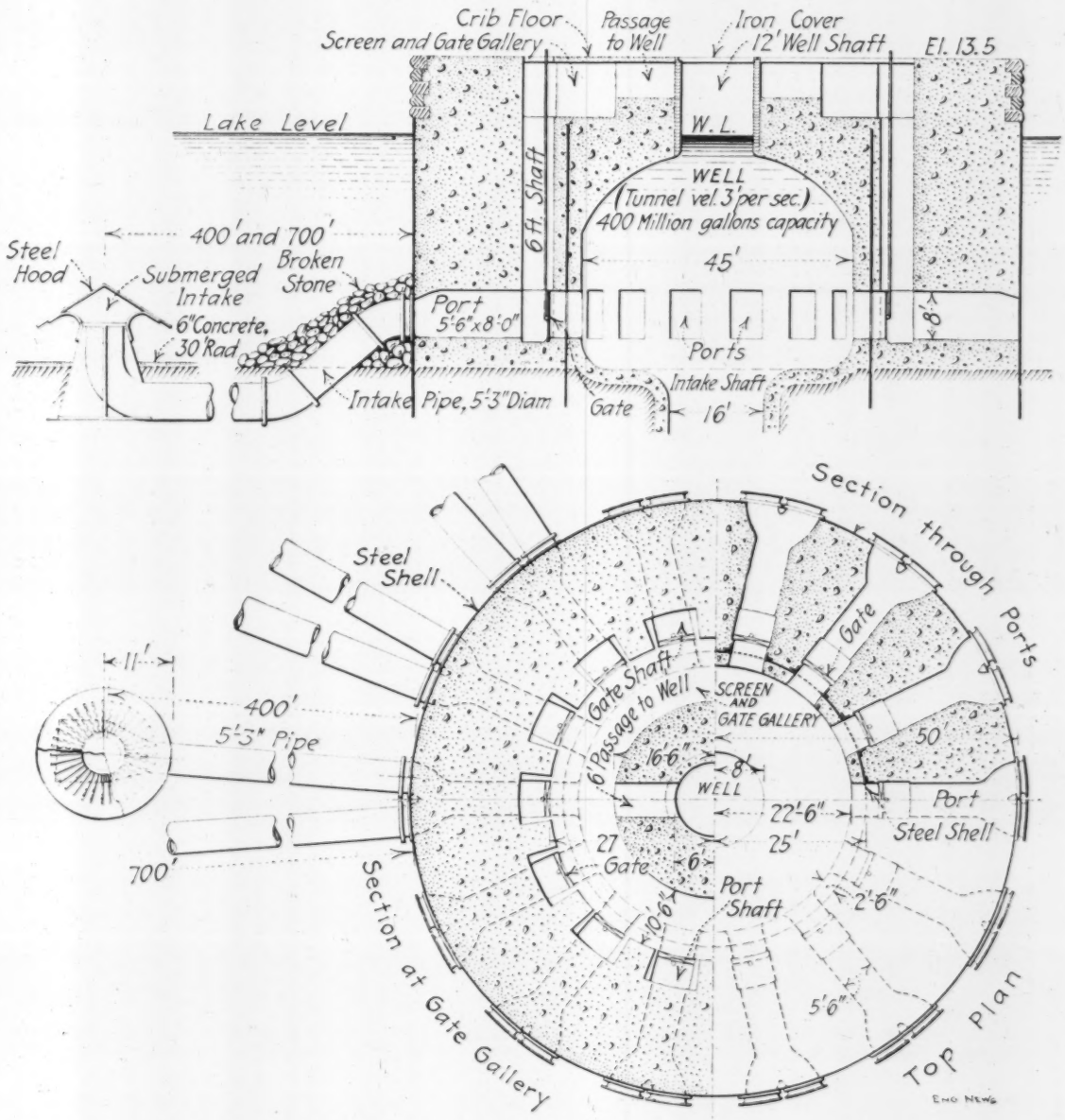

Fig. 3. Proposed Design of Crib for the New Water-Works Intakes at Chicago
(W. D. Barber, Assistant Engineer, Department of Public Works, Chicago; designer.)

During some storms the screens have to be cleaned about every half hour. This material includes paper, straw, horse manure, etc.

68th St. Crib: Anchor ice forms here when it does not at the adjacent Dunne crib, owing to the extra velocity of water in the ports of the former. The water is roiled during long storms.

Dunne Crib: Anchor ice causes trouble here at times. The water conditions are the same as at the 68th St. crib.

Proposed New Design of Intake Crib

The drawing in Fig. 3 shows a new type of crib which has been designed to overcome the difficulties and objections to the ordinary type, and which represents the pre-

liminary design for the proposed three-mile crib off 35th St. This crib would be 100 ft. in diameter, with a 15-ft. well, and a 12-ft. shaft from the top of the well to the crib floor, while the intake shaft opening into the bottom of the well would be 16.2 ft. in diameter. The ports and the opening into the intake shaft have been designed to give a smooth and even flow of water to the tunnel, with a minimum of obstruction or interference to flow.

Its distinctive features are the following: (1) The use of radial intake pipes with submerged intakes 400 to 700 ft. from the crib, so as to increase the area of supply and thus reduce the suction effect; and also draw all the water from near the bottom of the lake. (2) The shape of the intake well, and the covering in of the well so as to reduce the amount of waste space in the crib surface. (3) The direct communication of the well with the intake shaft, thus eliminating the usual intake which forms an extension of the shaft rising into the well and fitted with gates. (4) The provision of gates and screens in the intake ports, and the use of a shaft to allow of raising the gates and screens above the surface for cleaning or repair, and to avoid having such work done in the well.

It is of interest to note that the Harrison crib (of the old type), with a diameter of 112 ft., provides a flow capacity of 152,000,000 gal. daily, with a velocity of 3 ft. per sec. The proposed crib, 100 ft. diameter, would provide a capacity of 400,000,000 gal., and the velocity in the intake ports would be only 1 ft. per sec., so that several ports could be closed (for repair, etc.) without reducing the capacity of the intake.

The points regarded as desirable in the designing of an intake crib are as follows:

(1) To locate the crib in water 50 to 60 ft. deep, where the supply may be drawn from sunken intakes placed below the influence of surface disturbances and the effects of undertow caused by storm conditions. The intakes to be protected against direct entrance of water from the surface.

(2) To design the ports with shafts for gates, screens and devices for cleaning and other work necessary, and to have these parts outside of the well area.

(3) To so design the intake shaft, well, and port entrances as to eliminate sudden changes in velocity and direction of flow, cross-currents, contractions, etc., that may affect the regular and uniform flow into the intake tunnel.

(4) With the changed design of the well, port construction and cleaning conditions, the superstructure may be changed to greatly reduce cost of construction and operation.

(5) To spread the intake area so that the water within this area will be changed very slowly, say once in 24 hours.

(6) To place the submerged intakes 400 to 700 ft. from crib and pipe the water to the port entrances. They would be beyond the limits of ice jams caused by the crib as an obstruction to floating ice.

It is proposed to form this crib of steel shells 100 ft. and 50 ft. in diameter, with the annular space between them divided by radial partitions into 14 water-tight compartments. The steel bottom would be placed above the lower edges, which would form a cutting edge to be pressed 5 to 8 ft. into the clay bottom of the lake. This steel structure would be built on shore. An intake port is provided in each compartment. On the outside of the outer shell are flanges for fastening the ports to pipes that lead to sunken intakes placed 400 to 700 ft. from the crib. On the inner shell of each compartment are steel frames and fittings for sluice gate for each port, with guides, etc., for gates and screens. These parts may all be built before the steel crib is towed out to its location.

When the crib is in position, the water-tight compartments will be permitted to fill with water in an even uniform manner so that the crib will settle gently into place. A flanged pipe pierces the bottom of each compartment so that when the cutting edge rests firmly on the clay bottom the water may be pumped from under the compartment, thus forcing the cutting edges into the clay and drawing the whole structure into its final position. The tops of the steel shells will then be 3 to 4 feet above the lake surface.

When this preliminary work has been done the water-tight compartments will be pumped out (one at a time). The ports, gates, screens, gate-shaft and other parts may then be built in place. Instead of filling the whole compartment or pocket with concrete, it would be more economical and just as serviceable to place about 4 ft. of concrete next each shell and around ports and gate shaft, and then fill the intervening space with broken stone, clay and sand (thoroughly puddled and tamped) up to the floor of the crib some 13.6 ft. above lake level.

When the pockets have been finished up to the floor of the screen and gate gallery, the space inside the inner steel shell may be pumped out, and the connection made to the intake shaft. This would be fitted above with fish-screen and sluice-gate gallery. Adjacent to the cleaning gallery would be an incinerating plant to dispose of material from the screens, as well as the garbage and refuse on the crib.

When the crib has been finished ready for the superstructure, the blank flanges may be removed from the thimbles at the intake ports and flanged couplings fitted for the intake pipes. It will be noticed that each port through the wall of the crib connects with two 63-in. pipes, thus doubling the number of sunken intakes as compared with port entrances. The number of these pipes and intakes might again be doubled, thus making the intake area more uniformly distributed in drawing its water supply to the crib.

This would permit the deep water in the lake within the area of the intakes to adjust itself slowly to this loss of water and disturb the surface as little and as slowly as possible. Extensive experiments would be needed to determine to just what extent this subdividing could be carried on to advantage as to cost and the elimination of difficulties caused by anchor ice. The intake pipes beyond the outer wall of the crib are to be laid in a trench excavated in the bottom of the lake. Around the crib for a distance of 50 to 75 ft. would be placed sufficient broken stone to protect these intake pipes from ice jams and other disturbances, the pipes entering the crib being entirely covered with this broken stone.

The outer end of each intake pipe would be turned up vertical and fitted with a steel hood to protect the inflow, as shown. The bars fastening the hood to the pipe would be of polished brass or some metal to which ice will not adhere. The lower side of the hood would

be lined with zinc or brass for the same reason. The hood is to be 22 ft. diameter and this distributes the area of inflow of each of the 28 intakes to a large area of lake bottom. Around each of the intakes concrete is to be deposited (by means of a tremie or chute) to a thickness of about 6 in. for a radius of 30 ft. The lower edge of hood would be about 30 in. above the concrete.

Heavy materials dropped from the surface would simply fall on the hood and roll away to one side. Lighter materials stand very slight chance of being carried under the hood by the inflow current. To prevent the formation of anchor ice in the hood and intake (in the event of such disturbance as to cause water to be drawn from near the surface), there would be a 2-in. pipe led along the intaake pipe for gravity flow from a hot-water tank on the crib to the hood. For any intake thus choked, the intake gate would be closed and hot water allowed to flow to the hood.

Buoys would be placed around the crib to warn vessels from anchoring within the area occupied by the intakes. In regard to the submerged intakes, it may be noted that practically all such intakes now in use have no protection or means of preventing the surface water from flowing directly into the intake. And all sunken intakes as now built are troubled at times with the formation of anchor ice.

The intake well being partly covered by the floor of the crib, the well room in the superstructure would be only about 20 or 24 ft. square, leaving only sufficient space to operate a hoist or crane for use in making repairs on the well, shaft or tunnel. This would extend up through the two-story superstructure, and above it would be the light tower. With this design, the building necessary for housing the operating force, well room, store rooms, etc., would occupy only half the space now usually devoted to this purpose, and half the surface area of the crib might be utilized as a garden for the use and pleasure of those living on the crib.

The elimination of trouble from anchor ice at the crib means that one crib keeper and his two assistants could handle the work throughout the year, instead of having to hire a much larger force during the winter. The staff is needed to place lights and meet other government requirements, and also attend to the cleaning of screens and other work. The cost of this 400,000,000 gal. intake crib would be practically the same as that of the Edward F. Dunne crib (300,000,000 gal.) , as the submerged intakes and outside piping would about balance the difference in cost of the crib proper.

The author has been in the employ of the city for some 17 years and has had charge of the construction of several of the intake tunnels. He realizes that little investigation has been made along the line eliminating the numerous defects and difficulties encountered at the present cribs, but has sought to devise a new and better structure for the purpose.

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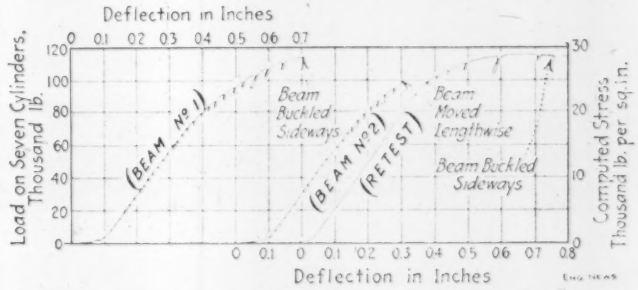
Through Train Service between New York City and points in eastern New Hampshire and Maine and the North Station in Boston will be inaugurated on June 23, through the completion of the new Hampden R.R., extending from Springfield, Mass., to Bondsville, 16 miles. Through trains over the New Haven system will connect with the Boston & Maine system at Bondsville, so that passengers from New York City and farther South can travel to Maine and New Hampshire summer-resort points without change of cars. The distance from New York to the North Station in Boston by this route will be 234 miles, as compared with 232 miles by the Shore line.

Bending Tests of Two I-Beams were made recently by the Iron City Testing Laboratory, Pittsburgh, for Hindman-Henderson Co., of the same city. A uniform-load testing machine was used, having seven hydraulic plungers applying equal loads at the eighth-points. The I-beam section was somewhat unusual, being 20 in. deep and weighing 59 lb. per lin.ft. (nominally.) Deflections were measured at all stages of loading, and autographic curves of deflection taken. These show complete straightness up to an extreme-fiber stress of 31,000 lb. At 49,000 to 51,000 lb., the two beams (which had deflected laterally throughout the tests) failed, by jumping out of the machine sideways. The curves (see cut) in-



AUTOGRAPHIC LOAD-DEFLECTION CURVES FOR TWO 20-IN. BETHLEHEM I-BEAMS, SHOWING HIGH FLEXURAL ELASTIC LIMIT

dicate, however, that this failure point was close to the normal ultimate. The deflections of the two beams differed slightly, which result is attributed to differences in manufacture. Moduli of elasticity of 28,000,000 and 25,000,000, for the two beams respectively, are reported. The following table of weights and properties of the section, and their departures from nominal values, may be of interest:

	Nominal	Beam 1	Beam 2	Mean Departure
Depth, in.	20	19.54	19.64	2% low
Weight, lb. per ft.	59	54.3	54.3	8% low
Flange width, in.	8.0	8.1	8.1	1% high
Web thickness, in.	0.375	0.389	0.389	3% high
Area, sq.in.	17.36	15.79	15.91	9% low
Moment of Inertia, in.⁴	1172.2	1023	1011	13% low

The tests show that I-beams may have perfectly elastic and normal character practically up to the tensile elastic-limit value of the metal, in spite of the existence of irregularities, internal stresses, etc., evidenced by irregular or inconsistent deflections. The test thus tends to set at rest some of the doubts raised by the tests of Prof. E. Marburg ("Engineering News," Aug. 12, 1909, p. 168) when very low values of elastic limit were found in bending tests of I-beams. However, published tests of I-beams are too few in number to allow of very positive conclusions.

A Temporary Rolling Drawbridge of the retractile type, moving in a horizontal line across the river, is to be built over the Chicago River at Madison St. to accommodate foot traffic during the removal of the present swing bridge and the construction of the new bascule bridge. A pile trestle south of the present bridge will extend from the west bank to the line of the old center pier, and the rolling draw will form the east connection, providing a 70-ft. opening for navigation.

The construction will be very similar to that of the Milwaukee River drawbridge described in our issue of Jan. 30, 1913. The drawspan will have steel trusses 70 ft. long, with a walk 11 ft. wide between them, and one end of the span will be mounted on a pair of car trucks traveling on two standard-gage tracks on a trestle parallel with the present east approach to the bridge. The city owns a large yard south of the approach which is used to store material for the Bridge Department, and this yard provides a convenient site for the trestle carrying the tracks on which the draw will run. The span will be balanced by a counterweight on the short arm, behind the trucks. The operating mechanism will consist of a hoisting engine and cable connected to the trucks, and it is expected that the bridge can be operated in about one minute.

The plans for this temporary drawbridge have been prepared under the direction of Alonzo J. Hammond, Engineer of Bridges and Harbor. The removal of the present bridge has been ordered by the War Department in furtherance of its policy for the improvement of the Chicago River channel by taking out all center piers and similar obstructions.

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Instruction in Methods for the Prevention of Accidents must be given by the teachers of the public schools of New Jersey, 30 minutes during each month hereafter, according to a bill passed by the legislature of 1913.

Bank Strengthening on the New York Barge Canal

Rather extensive work in driving sheet-piling in canal embankment has been begun on the western division of the New York State Barge Canal.

CONTRACT 112—A contract covering the driving of about 145,000 lin. ft. of steel sheet-piling (12 in. wide) was let recently to John Young, of Syracuse, N. Y., which applies to the original canal contracts 60 (near Spencerport) and 66 (between Gasport and Lockport). The sheeting will be driven in a single line, extending along some 5100 ft. of canal bank that is higher than ordinary or is of such character as to be thought to call for precaution against seepage and washout. Piles 16 to 24 ft. long will be driven. The Chesley Construction Co., Buffalo, is doing the work under subcontract.

ALTERATION CONTRACTS—A similar piece of work done as an alteration of an existing contract (contract 77) is being constructed by the T. A. Gillespie Co., at Palmyra, where about 6000 ft. of canal bank are to be strengthened by a line of 6-in. wooden sheeting 18 ft. long. A similar alteration is being carried out by H. S. Kerbaugh Inc., on contract 63, involving the reinforcement of 7600 lin.ft. of bank between Fairport and Bushnell's Basin by steel sheeting 16 to 24 ft. long. Similarly about 5000 ft. of bank on contract 61 at Brockport (contractors, Cleveland & Sons) are to be reinforced with steel sheeting 12 to 20 ft. long. The work here is being done on subcontract by the Horton Construction Co., of Buffalo.

The total of the sheet-pile reinforcing on the Barge Canal work covers nearly 24,000 lin.ft. of canal bank and involves a cost in the neighborhood of $100,000.

The sketch (Fig. 1) herewith illustrates the general arrangement of the steel sheeting. It applies to the conditions as found on contract 61 at Brockport, on contract 63 near Bushnell's Basin, and on the special piling contract 112. Here the new barge canal occupies the same alignment as the Erie Canal. On contract 61 the widening (from Erie width to Barge Canal width) was mainly on the side shown, while on contract 112 and contract 63 the widening was done on the opposite side and the sheeting therefore is driven mainly in old bank. In two of the contracts (61 and 112) the bank is being built somewhat higher than the old bank, as the water-level of the canal will be raised about 2½ ft. to secure the increased canal depth; on contract 63 the water-level remains about the same and the canal is dredged for the extra depth.

The intention throughout is to carry the sheeting to or below the canal bottom, and into the original ground surface or the embankment of the old canal.

Fig. 2 shows the conditions existing on contract 77 just east of Palmyra. Here the Barge Canal departs from the Erie Canal and occupies the straightened alignment of the old channel of Canargua Creek, crossing and recrossing at many points. There was not enough material in the original excavation to complete the north bank to the full intended cross-section, and this had the result that during the March, 1913, flood the partially completed bank was washed out at one of the places where the canal alignment crosses the creek channel, the fill here being, of course, higher than shown in Fig. 2. The wooden piling is being driven to give additional security against another scouring-out of the bank. The banks will, however, be filled out to full section later when additional spoil is available. The channel in this section is now open for use as part of the Erie Canal, connecting with the old Erie at Macedon on the west and at East Newark on the east.

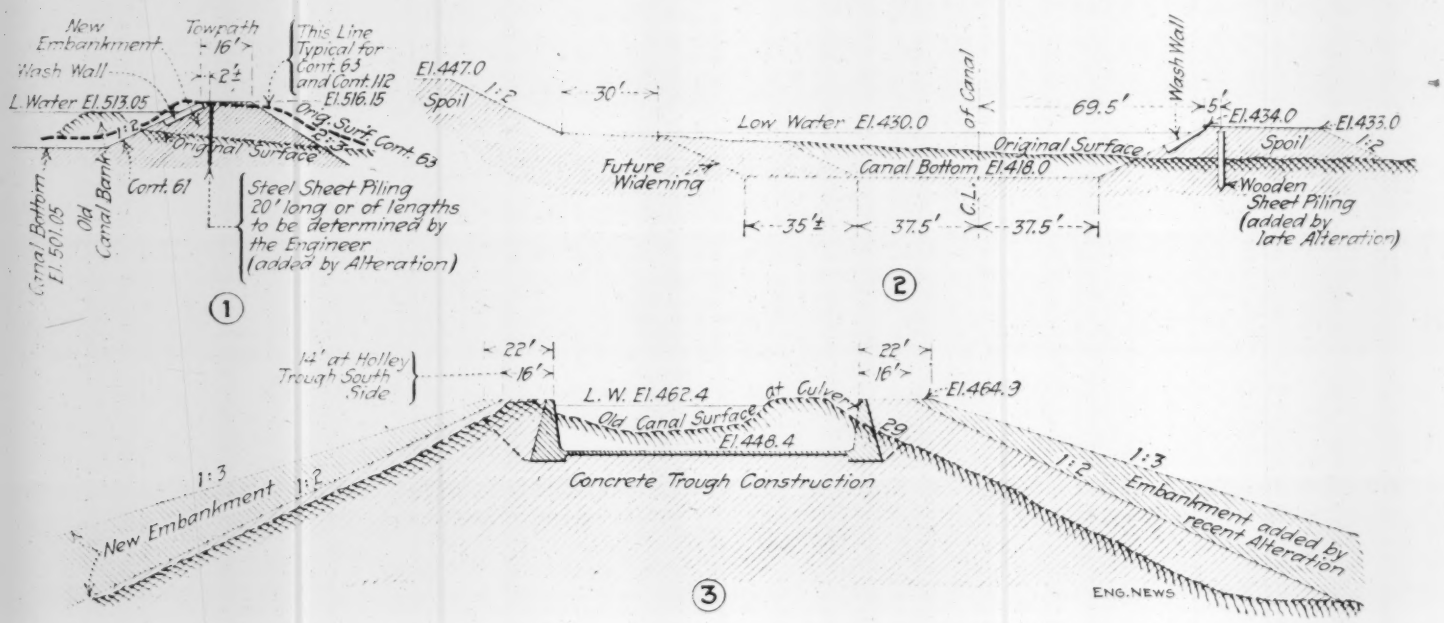

FIG. 1. SKETCH SECTION OF NEW YORK BARGE CANAL BANK SHOWING RELATION OF STEEL SHEET-PILING TO ORIGINAL CONSTRUCTION

FIG. 2. TYPICAL SECTION ON CONTRACT 77, SHOWING WOODEN SHEET-PILING NOW BEING DRIVEN

FIG. 3. CONCRETE TROUGH SECTIONS, AND EMBANKMENT WIDENING

(Irondequoit, Holley, and Culvert 29)

VERTICAL SIDE-WALLS INSTEAD OF PAVED SLOPES—At a section in high embankment at a creek crossing (culvert 29 at Bushnell's Basin) the canal prism was originally planned to be secured against seepage of water by revetting the side slopes and the floor with concrete.

Since then, however, experience has been had with concrete trough construction having vertical side-walls, and the section at culvert 29 has been changed to one with concrete trough.

STRENGTHENING OF EMBANKMENTS—Several high embankments at culvert crossings are being strengthened by flattening of the side slopes and widening the embankment on top. This is true at Irondequoit, at culvert 29 and at Holley. The sketch Fig. 3 illustrates the change. The usual widening is from 14- or 16-ft. top width to 22-ft. width and the side slopes are being flattened from 1 on 2 to 1 on 3. At the two last-mentioned points the culverts will be extended to suit the increased width of embankment. The three points above-mentioned are the locations of the three concrete troughs built in connection with the barge canal.

The break at the Irondequoit Creek crossing, reported in our issue of Sept. 19, 1912, is now being cared for by a timber flume, built last September. It will ultimately be spanned with a concrete aqueduct in place of a new culvert with a new embankment.

SPECIFICATIONS AND COST OF SHEETING—The bank reinforcement by driving steel sheeting is being done under the following special specifications:

SPECIAL SPECIFICATIONS

Upon points in which these special specifications conflict with the general specifications, the provisions of the special specifications shall prevail, and those of the general specifications in conflict therewith shall be void and of no effect.

The work under this contract shall be completed by May 10, 1913, and all equipment and materials removed from the towpath by May 15, 1913. In case the work is not progressed at such a rate as will insure its completion as above specified, the state will exercise its rights under clause 11 of the contract.

Twelve-Inch Steel Sheet-Piling shall be composed of medium steel of a quality acceptable to the engineer and shall be subjected to surface inspection. It shall be of some standard type which has been satisfactorily used in other works and the least thickness of metal shall be three-eighths of an inch except on tapering edges. The heads of the piles when driven shall not project above, or more than 6 in. below the elevations shown for them on the plans. Piling shall be furnished in lengths to fit the locations and shall be of such dimensions as will give a distance of not less than 12¾ in. from center to center of piles, measured along the line of the piling. It shall be driven so that the top will be as nearly as possible at the elevations shown on the plans. All piles which project above this elevation shall be sawed off.

The contract price per linear foot of pile for **12-in. steel sheet-piling** shall include the cost of all labor and materials necessary to furnish, drive and cut off the piling as herein specified or shown on the plans. The cost of all excavation and backfilling necessary to place the piling shall be included in the contract price for **12-in. steel sheet-piling.**

The following are the contract prices for the steel sheet-pile work:

Contract 112, steel sheeting 16 to 24 ft. long, 83c. per lin.ft. of 12-in. pile driven.

Alteration of Contract 63, steel sheeting 16 to 24 ft. long, 90c. per lin.ft. of 12-in. pile driven.

Alteration of Contract 61, steel sheeting 12 to 20 ft. long, 90c. per lin.ft. of 12-in. pile driven.

The work is under direction of E. J. Govern, Division Engineer, Western Division, Rochester, N. Y.

The work above described is progressing and will soon be completed. No particular difficulty has been encountered, but in driving the long 24-ft. steel sheeting through very hard embankments some shattering of the web at the top has been experienced.

The use of sheeting is not new in the Barge Canal work. Sheeting in banks has been driven both under original construction contracts and—where the necessity for such additional protection developed—under alterations of original contracts. The present work, however, is new in being the reinforcing of old (Erie) canal banks at places where they are practically unaltered in the Barge Canal work. The use of steel sheeting is also largely new, as most of the canal sheeting that has been put in was wooden sheeting.

A Water-Works Company Which Advertises

Gas and electric-lighting companies make free use of advertisements in the local press to extend their business but water companies do comparatively little of this kind of advertising. A notable exception is the Terre Haute Water Works Co., of Terre Haute, Ind. A recent example of the advertising done by the company just named, and one which has particular interest just now in view of the recent floods (see notes from Dow R. Gwinn, p. 742 of our issue of Apr. 10, 1913) is reproduced herewith.

16 THE SATURDAY SPECTATOR April 19, 1913

"THE PUBLIC BE PLEASED"

It is our desire to furnish the best possible service to our patrons, and with that idea in mind we are keeping in touch with the best thought in Water Works design and construction. We want to make the Terre Haute plant as near perfect as it can be made. As we learn by study, observation and experience, we make improvements to our plant so that we can have better service. Two of our officials have been in the water business over thirty years, and several of our men have been with the company for more than a score of years.

We have a good plant, and, what is of equal importance, a trained force of men that can be relied upon.

It was said that the water supply in 10 cities of Indiana was out of service during the recent flood. We maintained the usual pressure, but not the usual standard of purity. At the end of three days, we were again furnishing the high grade of water which has been so satisfactory to our patrons. The results will be interesting to some, so we give the record, since the settling basin pump was started, as made by our Bacteriologist.

Efficiency of Filtering and Purification Process

Date	Pct. of Efficiency.	B. Coli
March 29	99.9	None
March 30	99.9	None
March 31	99.4	None
April 1	99.6	None
April 2	99.3	None
April 3	99.7	None
April 4	99.9	None
April 5	99.1	None
April 6	98.2	None
April 7	98.6	None
April 8	97.2	None
April 9	97.5	None
	Average 99.0	

Water purification is only one of our hobbies, and we believe our customers appreciate what we try to do. As a result of the purifying process, the bacteriological tests show the water delivered through the mains during 1912, averaged 98.4 reduction of bacteria, something a little nearer perfection than we poor mortals attain personally.

We have a feeling, however, that we should make such changes and improvements in our plant that will enable us to not only furnish plenty of water during floods, but *water of the unusual standard.* We will fall short of our ideals if we fail in doing so.

And we want to tell our friends and patrons that we are even now making minor improvements and are planning more extensive ones, with the hope of being in a position to avoid a repetition of the recent experience. The flood was unprecedented, and we may not have another like it in the next 100 years, but we want to be prepared for an even greater flood.

By the way, good water service is a good advertisement for a city, and with us good service is a duty and an obligation.

TERRE HAUTE WATER WORKS CO.

AN EXAMPLE OF WATER COMPANY ADVERTISING

The Machinery Building at the Panama-Pacific International Exposition will have nearly eight acres of floor space. In addition there will be an auxiliary structure to be known as the Gas and Fuels Building. Electrical machinery will be located in the main building, which will be served by adequate crane facilities. Power will be available in the form of alternating and direct current, gas and water in this building, while steam and compressed air will be provided in a section adjacent to the Gas and Fuels Building.

Filling a Tunnel Cave-in by the Hydraulic Method

By Donald F. McLeod*

In locating the new 24-in. Potters Falls pipe line of the water-works system of the city of Ithaca, N. Y., it was found convenient to avoid a sliding clay deposit on a steep bank by tunneling behind the deposit. The tunnel, shown in plan in Fig. 1, is 170 ft. long. Its cross-section (Fig. 2) is nearly oval, and is 6 ft. high by 5 ft. in greatest width. The lining is of reinforced-concrete 6 in.

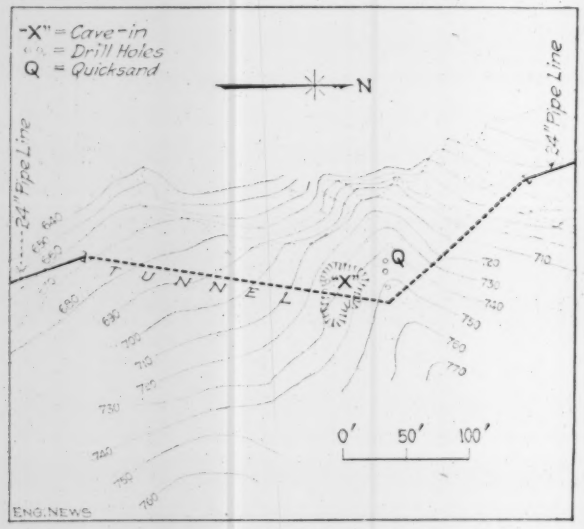

Fig. 1. Plan of the Tunnel on the Potters Falls Pipe Line, Ithaca, N. Y.; Showing Location of Quicksand Deposit

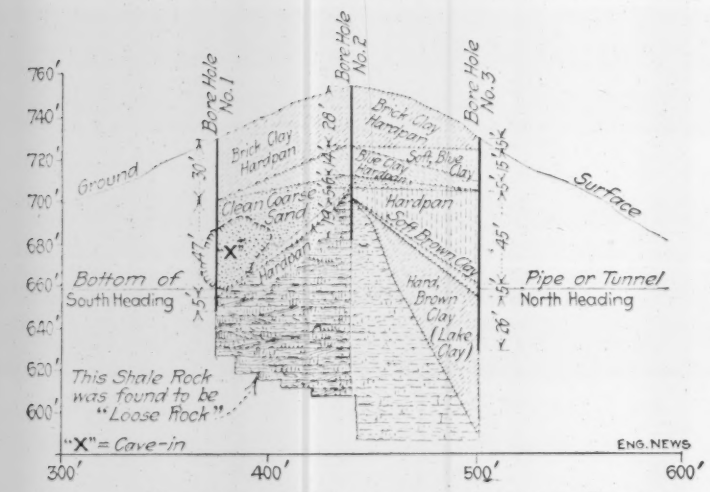

Fig. 3. Section of Material on Line of Tunnel as Indicated by Test Borings

thick. The greatest depth of cover is 100 ft. Preliminary borings showed that the material consisted of glacial clay, hardpan, gravel and sand. The lining was designed to resist a pressure equivalent to a head of 40 ft. of water, but before the tunnel was completed the lining was put to a test not contemplated by the designer.

Although the preliminary borings showed a deposit of sand over 40 ft. deep (Fig. 3), the contractor (who had little faith in the record of the borings) made no preparations for encountering this deposit. When the north heading struck it, about a foot from its indicated position on the profile of the borings, there was no timber casing in the heading and no provision for bulkheading. The result was that the sand, which was full of water, rushed out and filled the heading for a distance of about 40 ft.

Instead of working on the south heading and giving the sandy deposit a chance to drain out through the north heading, work was continued on the latter. The heading had just been cleaned out, up to the face, when another outrush of sand occurred, similar to the first. The work was then completed from the south heading, the workmen being protected by a timber casing, inside of which the concrete lining was built. The cavity left by

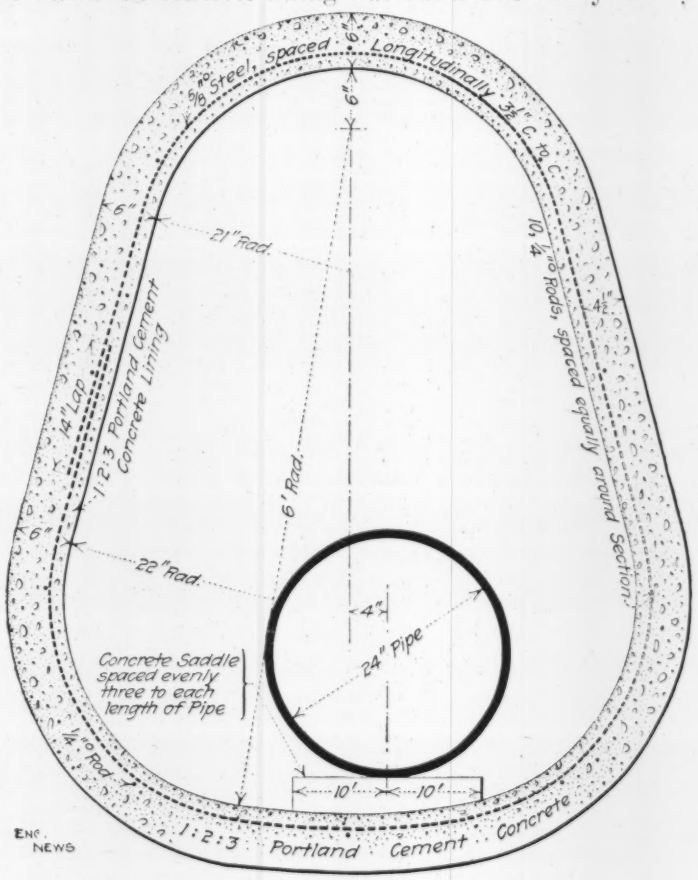

Fig. 2. Cross-Section of Tunnel for Pipe Line

the outrushes of sand was irregular in form and had a maximum height of over 30 ft. above the tunnel.

After the tunnel lining had been completed through the cavity, and the concrete had been allowed to set for several weeks, the cavity was back-filled by sluicing wet sand from the surface, in the following manner: A point was located on the surface of the ground as nearly as possible over the highest part of the cavity, and a hole drilled through, using an ordinary 5-in. well drilling outfit. The bore hole, which was about 60 ft. deep to the top of the cavity, was cased in the ordinary manner.

There was a large deposit of very fine, silty sand within a distance of about a thousand feet, and this sand was hauled in dump wagons to the bore hole. Tank wagons were used to haul water from a small stream. A wooden box, of the form used for mixing concrete, was set up, and in this the sand and water were mixed with hoes to about the consistency of wet concrete, so that the mixture would flow down a wooden trough into the bore hole. When the cavity was nearly full, care was taken not to let the muddy filling material rise in the casing above the top of the cavity, for fear of putting extra pressure on the tunnel casing.

No difficulty was met with, and the cavity was com-

*City Engineer, Ithaca, N. Y.

pletely filled. The amount of sand deposited, as estimated by the number of wagon loads brought on the work, was 142 cu.yd. The capacity of the cavity, as estimated from cross-sections made by a survey party, was 148 cu.yd. The concrete casing of the tunnel stood the strain without any damage. The backfilling was completed May 10, 1912. An inspection made in January, 1913, showed all the tunnel lining to be in good condition.

The location of the Potters Falls pipe line was made by the writer, as was also the design of the tunnel.

Cutting a 20-in. Water-Main Connection into a 20-in. Tee

An interesting piping problem was recently solved by the use of a pipe-tapping machine at water-works of the Bethlehem City Water Co., South Bethlehem, Penn. The population of the city has increased quite rapidly since the filters were constructed in 1904, and the plant is now taxed to very nearly its full capacity.† The filtered-water reservoir holds only about enough water for 24 hours' consumption, and should any accident or some other reason make it necessary to draw off the water from the reservoir, the city would be left without a supply of filtered water.

The full lines on the accompanying sketch plan show the piping layout at the water-purification plant. Both upper and lower reservoirs are surrounded by concrete walls, and in the narrow space between is a riprapped embankment, leaving a space only about 5 or 6 ft. wide at the tee-connections where the pipes could be made accessible without entailing large expense and difficult work.

For obvious reasons it was desired to make a direct

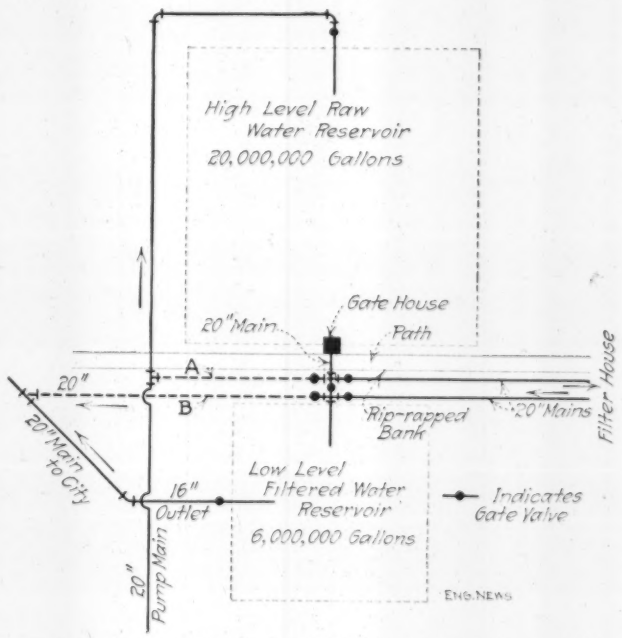

FIG. 1. SKETCH PLAN OF PIPING, BETHLEHEM CITY WATER CO. PLANT, SOUTH BETHLEHEM, PENN.

connection between the filter plant and the 20-in. main supplying the city, so that filtered water could be passed into the main without going through the storage reservoir. It was also desired to connect the incoming pump main direct to the filters to provide for any emergency which would necessitate the emptying of the raw-water reservoir.

From the peculiar location of the plant on top of a hill, and the difficulties imposed by the original layout, these connections could not be made except by crosses in place of the tees in the constricted passageway between the two reservoirs, or by the redesign of the entire piping system. Moreover, to dig into the retaining walls, take out the necessary sections of pipe to remove the tee-connections and replace them with cross-connections would have meant shutting off the entire water-supply of a city of 30,000 inhabitants for at least a day, with the possibility of an accident making the time much longer.

The problem was finally solved by cutting 20-in. openings into the backs of the two tee-connections, and mak-

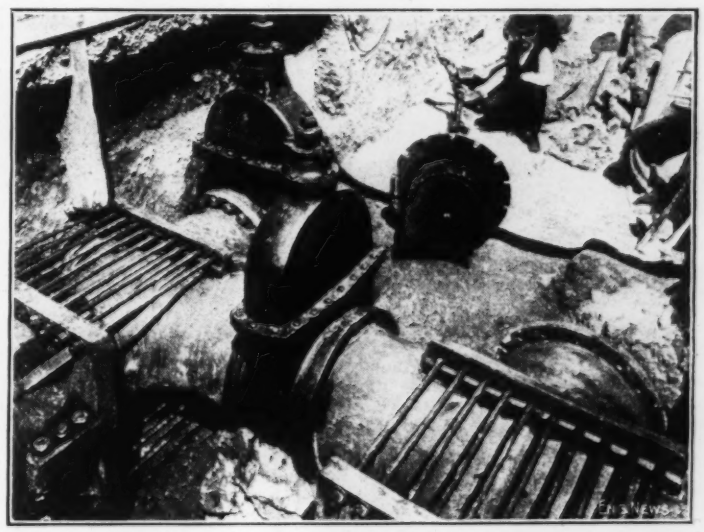

FIG. 2. VIEW OF PIPE-TAPPING MACHINE CUTTER WITH ONE 20-IN. CONNECTION COMPLETED

ing a regular 20-in. pipe connection. The work was done by the Water-Works Equipment Co. of New York City, by means of its pipe-tapping machine.

This machine has been used extensively for tapping straight pipe in diameters up to 48 in., and under almost any pressure met with in city water-works systems. The operation of tapping a straight pipe, using an inclosing sleeve, tee-connection and gate valve, is familiar to water-works engineers, and has been fully described in past issues of ENGINEERING NEWS,* but up to this time the company named had not been called upon to make a full diameter cut on the back of a tee-connection.

Fig. 2 shows the left-hand connection completed and the collar and half-sleeve in place for making the right-hand connection. The only difference in the method regularly employed was the necessity of a specially designed sleeve connection which is shown in the view. The steel collar is made of a two-piece casting bolted together and is joined to a special half-sleeve, made like the ordinary sleeve connection, except that it goes but halfway around the pipe. The collar bears against the bell of the old tee-connection and is joined to the half-sleeve by twenty 1-in. steel rod bolts, 10 above and 10 below. These castings once in place, the procedure is identical with the now common practice of pipe tapping.

†A brief description of the Maignen slow sand filtration plant at South Bethlehem, may be found on page 1284 of this issue, in an article describing a "Traveling Filter-Sand Agitator."

*A description of a power-operated pipe-tapping machine and the procedure in making a 30-in. connection with a 30-in. main at Trenton, N. J., may be found in our issue of Apr. 12, 1906, p. 412.

Further Data on the Long Beach Pier Floor Collapse

The pier floor collapse at Long Beach, Calif., which on May 24, 1913, caused the death of 38 persons (three more having died since the report in ENGINEERING NEWS, May 29, 1913, p. 1115), has been investigated by a committee of experts appointed by the local authorities. From their report and from additional information that has come to us, it is evident that the structure was deplorably weak, not only for the extraordinary crowd that was on it at the time of failure, but for any ordinary load.

The measurements of the panel which fell, given in our

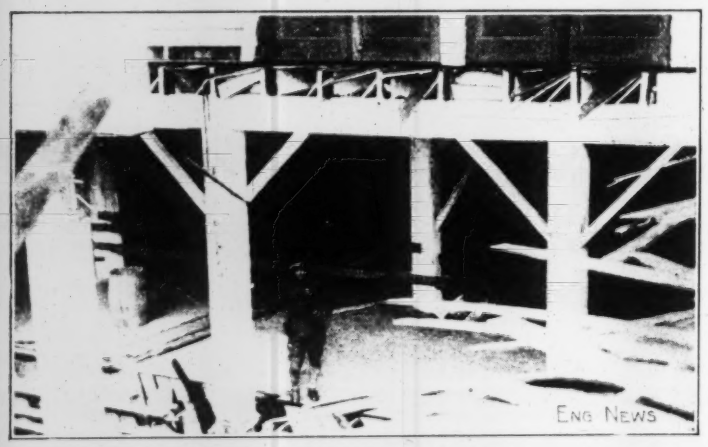

FIG. 1. EDGE OF THE BREAK IN FLOOR OF LONG BEACH PIER

previous article, were practically correct. With a few changes noted in a later measurement, the design was as follows:

A floor of 1-in. rough plank with a 7/8-in. tongue-and-groove topping, rested on 2x12-in. joists, 24 in. c. to c. and poorly bridged, which in turn rested on a girder made up of two 2x14-in. sticks, 18 ft. 6 in. c. to c. of 12-in. posts. The girder framed into a mortised bearing in the posts, 4 in. deep, giving a 4x4-in. bearing there, and was additionally supported by 3x4-in. knee braces, 36 in. long from face of post to the end of bearing on bottom of beam. The joists on either side of the girder spanned 11 ft. 3 in. and 15 ft. c. to c. of girders. The vertical distance between floors was 13 ft. and the lower floor, which collapsed under the impact of the falling upper floor, was 7 ft. from the sand beneath.

With the aid of the accompanying view and the above data, the following abstract of the report of the examining experts will readily be understood:

The building does not at all agree with the plans and specifications furnished us. There were evidently many items omitted and changed from what the contract called for, but certain portions of the building are stronger than specified. The entire construction leads your committee to believe that the stresses and strains were never properly computed.

It appears that the main members had a safety factor of approximately two, whereas good engineering practice requires a safety factor of six.

However, the connections had even a smaller safety factor than two. In other words, girders which are 4x14 in. should have been 13x14 in. and floor joists resting on these girders should have been 2x14 in. and not 2x12 in.

The cause of the failure was the breaking of a 4x14-in. girder at its support on a post in the center of the wrecked section. This girder had entirely decayed for some inches outside of its seat on the post, and all its load was being carried by a 3x4-in. angle brace, which was imperfectly connected.

There was a 2x14 in. scab or splice 24 in. long, tying this girder to the adjoining girder, but this scab had no bearing on the post, and so was affording no assistance in carrying the load. However, this scab effectually concealed from detection by a casual examination the rottenness of the girder which failed.

It would have been a simple matter to have detected this decay, if proper minute inspection had been made by one familiar with such work.

The excessive decay of this girder was doubtless caused from the fact that the floor above had no drainage and, as we understand, after each rain, water stood for quite a time over this portion, slowly percolating into the joints. The top of the post shows a marked degree of decay.

The weakness of the existing knee-bracing, and the total absence of adequate bracing at right angles to girders, contributed to the failure of the remaining portion.

As the direct cause of this accident is so apparent it seems unnecessary to seek for contributory cause.

Had the lower floor been properly constructed it would have withstood the impact of the falling load, but the girders of this floor had such poor support the wonder is that it held under ordinary usage. Had the lower floor remained intact, we believe the accident would have been far less serious.

No minute inspection of other portions of the building or approaches was made, but enough was noted to justify your committee in recommending that the building be condemned.

ALBERT C. MARTIN.
W. H. AUSTIN.
CHARLES E. RICHARDS.

Fig. 1 is a view of the break, showing at the top the doors to the auditorium, outside which the crowd was massed. The isolated 12x12-in. post in the left fore-

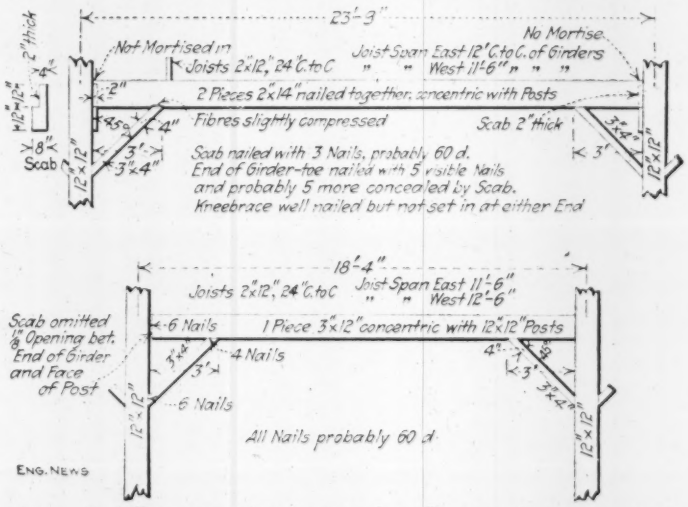
23'-3"
No Mortise.
Not Mortised in
Joists 2"x12", 24" C. to C.
Joist Span East 12'-6" C. to C. of Girders
" " West 11'-6" " " "
2 Pieces 2"x14" nailed together, concentric with Posts
Fibres slightly compressed
Scab 2" thick
Scab nailed with 3 Nails, probably 60 d.
End of Girder-toe nailed with 5 visible Nails
and probably 5 more concealed by Scab.
Kneebrace well nailed but not set in at either End
18'-4"
Joists 2"x12", 24" C. to C.
Joist Span East 11'-6"
" " West 12'-6"
Scab omitted 1/8" Opening bet. End of Girder and Face of Post
6 Nails
1 Piece 3"x12" concentric with 12"x12" Posts
4 Nails
6 Nails
All Nails probably 60 d
ENG. NEWS

FIG. 2. TYPICAL SECTIONS OF FLOOR SYSTEM AT LONG BEACH PIER

(These sections are at the lower floor which is not used for dancing or auditorium purposes.)

ground supported the girder which failed. The mortise which received the girder can be seen on the far side of the post, and a dark spot to be noted on the side of the post is where the knee brace was nailed.

In Fig. 2 are given two sections at the lower floor, which is not used for dancing or auditorium purposes. They are shown here to give some idea of the general design of the structure.

❖

An Improvement in Granite-Block Paving has been adopted in Philadelphia in the repaving of Broad St. between Cumberland and Silver Sts. The street was laid with granite-block paving of the old type with large blocks and wide joints. The old pavement was removed and the old blocks were cut in half and relaid with the cut end uppermost and the joints between the blocks were grouted with portland-cement mortar. The pavement obtained in this way has a much smoother surface than the pavement originally laid and the cost of the work was a little less than half the cost of laying a new granite-block pavement.

EDITORIALS

The Los Angeles Aqueduct: An Appreciation

The Los Angeles Aqueduct, to which a large part of our present issue is devoted, will long serve as a remarkable example of municipal enterprise and engineering ability. Boldly conceived to meet a far-seeing vision of municipal growth, boldly yet carefully designed to overcome unusual obstacles at a necessary minimum of cost, skillfully and conscientiously constructed amidst the manifold difficulties of the desert and the mountains in a hot, rainless region, and completed within the estimates of cost in record time, the Aqueduct will serve as a worthy memorial to its Chief Engineer, William Mulholland, and his able staff of assistants.

Mr. Heinly's article, with its numerous halftone views, its maps, profiles and cross-sections of the Aqueduct, does all that could be done in eleven pages of our space to picture the work as a whole and in its main details. No adequate conception of the magnitude, variety and difficulties of the Aqueduct construction can be gained, however, without traversing its whole length of 235 miles, from the intake opposite the high Sierras, across the sun-scorched deserts, along and over equally sun-scorched mountains and for scores of miles through the very mountains themselves, on down to the great terminal power plants and reservoirs.

When the writer of this note went the length of the Aqueduct somewhat less than a year ago, he found, as he expected to find, but as he had only inadequately anticipated, that the engineering conception and execution of the work was on a grand scale and painstaking and skillful in detail. What he was not prepared for was the whole-hearted way in which tunnel-drivers, pipe men, concrete gangs and all labor of high and low degree entered into their work. The spirit of these men and of their foremen and superintendents was the highest possible testimony to the devotedness and ability of the whole engineering staff, from the Chief Engineer and his able lieutenants down to the instrument men and rodmen.

We take all the more pleasure in making this brief note of appreciation, because of the abortive attacks which were made upon the character of the Aqueduct construction work a year or so ago. One of these was an attack by a local political faction, which, though unpleasant, was a common enough incident in connection with municipal work. The other attack was of a far different and more unusual character. It was an attempt to discredit the cement made in the municipal works, which entered largely into the construction of the Aqueduct, and with it to discredit the very integrity of the Aqueduct itself. This attack on the cement was all the more deplorable because it was made, if not indeed conceived, by engineers, in the interests of private cement manufacturers. It is a pleasure to note, however, that engineers throughout the West generally condemned both these attacks; and that engineers of both West and East, scores of whom have visited the work in question, unite in admiration and praise of the Los Angeles Aqueduct and its creators.

⁂

Engineers Wanted for the Work of Railway Valuation

When the Railway Valuation bill passed Congress, we called attention to the fact that it called for a greater amount of engineering work than any task ever undertaken. Recently we announced the appointment of the Board of five engineers which is to have general charge of this huge work. On June 12, the United States Civil Service Commission sent out announcements of the positions and salaries in the various grades of the engineering staff and invitations for applications from candidates for the positions.

The list of positions to be filled and the rated salary for each is as follows:

	Salary per annum
Senior Structural Engineer	$1800 to $4800
Senior Mechanical Engineer	1800 to 4800
Senior Railway Signal Engineer	1800 to 4800
Senior Electrical Engineer	1800 to 4800
Senior Civil Engineer	1800 to 4800
Senior Architect	1800 to 4800
Senior Inspector of Motive Power	1800 to 3600
Senior Inspector of Car Equipment	1800 to 3600
Architect	1080 to 1500
Inspector of Motive Power	1200 to 1500
Civil Engineer	720 to 1500
Inspector of Car Equipment	1200 to 1500
Electrical Engineer	1080 to 1500
Railway Signal Engineer	1080 to 1500
Mechanical Engineer	1080 to 1500
Structural Engineer	1080 to 1500

Necessary expenses when absent from headquarters in the discharge of official duties will be allowed.

Appointments to all these positions will be principally for duty in the field; but some candidates will be assigned to the general office force at Washington.

Applicants for positions commanding a salary of $1800 per year or over, in other words for the Senior grade, are not required to appear at any place for examinations but will be rated upon the evidence adduced as to their general and technical education and training and their practical experience and fitness. For the lower grades examinations are to be held on July 23 at all the places throughout the United States where such examinations are usually held, a list of which can be obtained from the U. S. Civil Service Commission at Washington upon application to any of its local offices.

For the Senior grade, two classes of eligibles will in general be established, one rated at salaries of $3000 per year and upward, the other at $1800 to $2700 per year. Applicants should state the grade for which they desire to be examined, but they will be admitted to the examination only for the grade or grades for which are shown by their statements of training and experience to be probably fitted.

In general, for the Senior rating, applicants should be 30 to 60 years of age for the higher grade and 25 to 50 years of age for the lower grade. There is some variation in these requirements for the different positions.

In general, also, for the Senior rating, graduation from a technical school and at least five years' practical experience, or if not a graduate at least ten years' practical experience is requisite. Engineers desiring to make application for any of the above named positions should make application at once for a copy of the announcement of the examination for the position they desire, and also for a copy of Form 2039. Applications may be addressed either to the United States Civil Service Commission, Washington, D. C.; the secretary of the Board of Examiners, post office, Boston, Mass.; Philadelphia, Penn.; Atlanta, Ga.; Cincinnati, Ohio; Chicago, Ill.; St. Paul, Minn.; Seattle, Wash.; San Francisco, Calif.; customhouse, New York, N. Y.; New Orleans, La.; Honolulu, Hawaii; old customhouse, St. Louis, Mo.; or to the chairman of the Porto Rican Civil Service Commission, San Juan, P. R.

The Ultimate Power to Regulate Railway Rates

The decision of the Supreme Court of the United States in the Minnesota Rate cases has been generally referred to in the press as endangering the value of railroad investments. It is true that the Court's decision is adverse to the contention of the railroads. Careful reading of the decision, however, reveals nothing radical in the principles enunciated by the Court.

The State of Minnesota, like a number of other States of the Union, has enacted laws fixing maximum rates for freight and passenger service on railway traffic within the State's borders. Such State regulation of railway rates has been practiced to a greater or less extent ever since the early days of the railway era in the United States. The passage of the Interstate Commerce Law in 1887, while it for the first time put in force the power of Congress to regulate interstate traffic on railways, did not interfere with the rights of the several States to regulate railway traffic within their own borders.

It is said, however, that a State, by its regulation of traffic within its own territory may control commerce passing over State lines. For example, Duluth, Minn., and Superior, Wis., are at about the same distance from the twin cities of St. Paul and Minneapolis. If now the Minnesota maximum rate law fixes a very low rate from Duluth, that city will have its commerce benefited at the expense of its rival city just across the State line in Wisconsin.

Instances without limit might be multiplied where the State's power may thus be exerted to affect interstate traffic. Where such cases occur, however, the Supreme Court says in its opinion just handed down that the authority of Congress is supreme when and where it chooses to exercise it. In fact Congress has already empowered the Interstate Commerce Commission to correct such interferences with interstate traffic.

To put it plainly, the attorneys for the railways appear to have blundered in appealing directly to the Federal Court for relief in the Minnesota rate cases instead of to the Interstate Commerce Commission. While the Supreme Court does not directly rule on the question whether the Interstate Commerce Commission has already authority under present Federal law to act in such cases, its comment that the Interstate Commerce Commission had not been called upon to act in the case is at least suggestive.

There is a strong tendency at the present time among railway men and financiers to look toward Federal regulation of railway affairs as a desirable result. That all public utilities are and ought to be subject to government regulation, is now well nigh universally admitted; and the possible conflicts between State and Federal regulation are well recognized. On the other hand, so long as State regulation confines itself to matters that solely affect local conditions within the State's limits and lets alone the matters that properly belong to the Federal jurisdiction as affecting interstate traffic, there is much to be said for continuing the dual control.

Furthermore, to quote a hackneyed saying, "it is a condition and not a theory that confronts us." With the present political complexion of Congress, there is small chance of the passage of any legislation which would wipe out entirely State authority over public utilities and substitute sole Federal control in its place. Nor is it at all certain that such a change would be a wise one. The division of responsibility between State and Federal authority, while it has its disadvantages, has also its marked advantages. In Great Britain, long experience has made plain the many objections to making the National Parliament the sole legislative authority over local as well as national matters. The reaction against this concentration of authority has become so strong that home rule for Ireland may yet be followed by home rule for Scotland, and there may be an even further delegation of local government matters to different localities within the Kingdom.

What is needed in the United States is a greater assumption of authority by the States over matters which they now neglect, and it is a serious mistake for the States to meddle with matters which should properly come under Federal control.

The Renaissance of Sand-Cement

The so called blended or sand-cements which are the subject of an article on another page of this issue by Rapier R. Coghlan, of the U. S. Reclamation Service, are not new, as any standard work on portland cement will show. In 1893 a patent was issued to T. L. Smidth, of the Danish firm of T. L. Smidth & Co., for a sand-cement which was made by grinding intimately together portland cement and sand or silica rock. Factories were built in various parts of the United States and a considerable quantity of the product used in various structures which, so far as we know, are standing today in good condition. Its use at that time died out because of the increasing production of true portland cement, which began to be made so cheaply that its price competition drove the blended cement out of the market.

Apparently its absence from the field of structural engineering continued until the last five or six years when the remoteness of several of the large structural developments in the Far West, notably those connected with the U. S. Reclamation Service, led the engineers to look into the subject with a view of producing a cement materially less in cost than the true portland cement which had to be carried so far that its cost was very high. As our readers well know, the experi-

ments and studies of the engineers of the Reclamation Service have led them to the adoption of a blended sand-cement on several of the large dams which are now under construction. Mr. Coghlan's article is a résumé of the studies which brought about this decision.

A distinction should be made between the old understanding of what this sand-cement is and how it acts and the present theory advanced by the engineers of the Reclamation Service. The early sand-cements were supposed to reach their strength and soundness, equivalent to the strength and soundness of a normal portland cement, because of the finer grinding which the regrinding of cement with sand brought about. The older books were not quite clear as to just why this finer grinding should make a normal cement out of a mixture of cement and sand, but they ascribed the fineness to a sort of ball mill action which took place when the sand and cement were ground together. The later idea, advanced by Mr. Coghlan, is that the rock or sand which is ground up contains a certain quantity of soluble silica, which combines with the freed lime of the setting portland cement to form a hard calcium silicate exactly in the same fashion as the assumed action in puzzolanic or tufa cement takes place. This is in complete distinction to the older theory which called a sand-cement a cement made by mixing a portland cement with an *inert* substance.

It is not for engineers to dabble in the intricacies of physical chemistry, particularly in those higher realms where the cement chemist roams. Suffice it to say that the latest investigators in cement chemistry claim that fine grinding will cause better cement by subdividing the hard cementitious particles and making them more reactive to water. Under this reasoning it is probable that some such action takes place as a result of the final grinding of the sand-cement, however much additional cementing power is added by the combination of the soluble silica. This is not successfully contradicted by Mr. Coghlan who merely shows that the finely ground sand or rock does not tend to fill up the voids in the cement. In fact, he admits that the particles are of finer grain in the blended cement, which is precisely the contention of the advocate of the fine-grinding theory.

While these theories are of academic interest to engineers, any experiments to show the effectiveness of the blended cement are of practical interest to them, and it is to be hoped that the Reclamation Service will continue in its study and that the Bureau of Standards will also take up a similar investigation.

The cement manufacturers have not taken kindly to the proposed improved cement, doubtless because of the fear that its use will result in a falling off in the demand for the true portland cement. On the face of it this would appear to be possible, for, using Mr. Coghlan's figures for plant and operation cost, it should be possible to produce a blended cement for $1.13 per barrel, where the portland cement which forms one-half of its volume costs $1.40 a barrel, a saving of 20%. On the other hand, the manufacturer of the blend requires machinery not available for the small user, so that no pronounced effect on portland cement production need be anticipated until the desirability of the compound becomes so evident that it will lead to its manufacture for commercial purposes, at which time the cement companies themselves will be the best equipped for entry into the business and participation in its profits.

It has not been proved as yet that blended cement is in every way as desirable as the true portland. On the other hand, the invidious term "adulterated cement" which some of the cement interests so freely use would sound better if there had been presented any tests which show the sand-cement to be inferior to the true portland. The engineering profession is not so enamored of the words "portland cement," or of the chemical and physical makeup of the product that bears that name, that it would not accept a substitute if that substitute produced a satisfactory concrete at a 20% saving in cost.

Maximum Load Assumptions for Ordinary Floors

It is an unfortunate fact that the design of the floor framing for ordinary wooden structures is, as a rule, left to the sole discretion of the carpenter builder. For the usual conditions of load, this is probably safe enough practice; but that it is extremely unsafe where the loading is beyond that of the ordinary dwelling house is very often demonstrated. The latest instance is the fatal pier failure at Long Beach, Calif., which was noted in these columns some weeks ago and is more fully described in this issue. In this particular case, the error was doubly reprehensible in that the floor was on a public pier and immediately in front of an auditorium door, where naturally a large crowd could be expected; whereas the floor to carry this crowd was hardly stronger than that which would ordinarily be used in a dwelling house.

In most cases, however, the trouble lies not so much in the design of the floor, but in the estimate of the load which that floor might reasonably be expected to carry. In fact, experience shows that it is not safe to assume any but a maximum load—that is, the largest load that a crowd can total—for any floor where people can congregate. For loadings of warehouses or similar structures the normal load of goods will, of course, be in excess of any load that people could produce.

Within the past two weeks, there has been an example of an unexpected maximum load which will bear description.

On Saturday, June 7, an international tennis match was held in New York City at the West Side Tennis Club, which consists of a great number of tennis courts and a small clubhouse designed only for the locker rooms and baths of the members and possibly for the simplest kind of entertainment. Immediately alongside the clubhouse, which is the only building or shelter on the entire grounds, there had been built a temporary three-sided grandstand, all but surrounding the court where the match was to take place, and capable of seating about 5000 people.

On the afternoon in question these stands were practically filled with people watching an engrossing match, so engrossing, in fact, that hardly fifty of the five thousand persons present left their seats until the threatening drops of a long imminent rainstorm turned into a torrential downpour, driving everyone to the nearest cover, which, as has been noted, was the little clubhouse. Soon all the floors and porches of this small building were packed to suffocation with hundreds of very wet people and the adjoining lawns filled with those anxious for admittance.

No one seemed particularly concerned for the strength of the floor until an ominous cracking under one of the porches drove the crowd thereon to the wetter but more stable turf outside. Fortunately, the movement was so rapid and escape so easy that the overstrained floor did no more than crack; but throughout the remainder of the storm the crowding in the building and the porches was decidedly less.

The point of this example is not that the porch was poorly designed for the load which it ordinarily carried—for we know nothing of the design of the floor—but that the clubhouse is ideally located for the assumption of a low maximum floor load. The porch in question is isolated, with an outlook upon an approach walk where little of interest might reasonably be expected to take place. A few hundred people ordinarily are present at the grounds or in the building, and at times of large tournaments, perhaps a thousand. But to have a sudden and terrific rainstorm come up when 5000 people—by far the largest crowd the grounds ever held—were forced to seek shelter in or around the building, was a coincidence which probably will never again occur; and it is a decidedly fortunate thing that it remained only a coincidence and not, as well it might, a terrible disaster. Had one of the three or four loaded floors collapsed under the unexpected crowd, there surely would have resulted nearly, if not fully, as many fatalities as occurred at Long Beach.

The Stamford Collision on the New Haven Railroad

The fatal rear collision on the New Haven R.R. at Stamford, Conn., on the afternoon of Thursday, June 12, is attracting wide attention, not only by reason of the casualties (which were surprisingly few considering the serious nature of the accident) but because of the circumstances under which the collision occurred.

In the first place the accident happened on the New Haven R.R., which, rightly or wrongly, is in very bad repute with the general public at the present time by reason of other fatal accidents on the road within the past three years, as well as because of its general conduct, financial and otherwise.

In the second place this collision occurred under the block system and under circumstances which leave no room for doubt as to the primary responsibility of the engine driver. It will be recalled that the two other very serious recent disasters on the New Haven road were likewise due to disobedience of block signals by the engine runners, although in the previous cases these signals required a slackening of speed for a crossover switch.

Briefly summarized, the circumstances of the Stamford collision were these: The first section of the westbound Boston express had stopped at Stamford to exchange its steam locomotive for an electric locomotive. Instead of getting away with four or five minutes delay as usual, it was held for some eighteen minutes so that the second section following overtook it. The standing section was protected by a home signal in the rear set at danger and a distant signal set at caution. The standing train, moreover, was perfectly visible to the engineer of the approaching train, the track being straight for a long distance and it being broad daylight. Nevertheless, the engineer of the second section ran past the danger signal and struck the rear of the standing train at a speed variously estimated at 12 to 20 miles per hour. The rear car of the standing train was a wooden Pullman parlor car in front of which were steel coaches. The locomotive telescoped the parlor car for nearly two-thirds its length, killing six persons and seriously injuring about twenty others.

It is, of course, to be expected that an engine runner who has caused a fatal accident under such circumstances will make the best defense he can for himself on the witness stand. The story of the engine runner, Dougherty, is briefly as follows: Both he and the fireman identified the distant signal at caution when they were a train length back of it and he then closed the throttle and let the train drift toward the home signal. We quote further from his testimony as reported in the New York *Times* as follows:

> It was straight track ahead. I could see the other train apparently right under the home-signal tower. I gave her the air and saw she was not taking it. After going maybe a car length I gave her the air stronger. The air didn't take hold. When I was 200 ft. away from the home signal I gave her the emergency. That put on the full force. I saw there was going to be a collision because she would not stop. I grabbed the sand-valve string and the whistle.
>
> After one long blast, I let go of the sand valve and held to the whistle still, waving my other arm out of the cab window to two trainmen I could see in the rear of the first section. I was praying they'd move out. I was trying to warn them. The two men saw a collision was coming and stepped aside from the track.
>
> That was all I could do. My train broke in two. I tried to reverse the engine, but my back wouldn't stand for it. I got the lever three notches up, but I failed then.

According to Dougherty's previous testimony, on the previous Tuesday, at South Norwalk, he had applied the emergency air brake on account of a child coming onto the track ahead and instead of stopping the train in two or three car lengths at the speed it was running, it ran to the lower end of the station platform before stopping. He also ran past the station at Bridgeport and had to back up two or three car lengths after the train stopped. After that he used greater caution and applied the air earlier than usual. He also wrote in the work book at Stamford "brakes no good; won't hold."

Later testimony by other engineers who had run the same train with the same locomotive on previous days was that its brakes had operated all right. Tests of the brake equipment are to be made as part of the official investigation.

The best comment of all on Dougherty's claim that the air brakes would not hold is the fact that his train broke in two after the emergency application of the brake was made before the collision occurred at Stamford. This is proof which cannot be gainsaid that there was no stoppage in the train pipes and that the air brakes on the cars at least were in good working order. It is also, however, circumstantial evidence that the air brakes on the locomotive itself may not have had adequate holding power. If, as Dougherty testified, there had been previous trouble with failure of the brakes to hold sufficiently, the cause is probably to be sought in improper adjustment or maintenance of the air brakes on the locomotive driving wheels.

It will be of interest to inquire also whether the locomotive had brakes on the leading truck and what was the condition of the brake on the tender. As those of our readers familiar with railway matters will recall, the ap-

plication of brakes to locomotive truck wheels was first introduced some twenty years or more ago as the result of a serious collision where official investigation showed that additional braking power on the locomotive might have prevented a bad disaster.

It should be clearly understood, of course, that these circumstances in nowise lessen the primary responsibility of Dougherty for the collision. He had been making station stops with the same train throughout the length of the run and he had a long distance in which to bring his train to a stop before reaching the home signal and striking the train standing beyond. If his train did not check its speed properly, as he testifies, when the service application of the brakes was made, he should then and there have applied the emergency instead of waiting until he was close upon the home signal. That his train would have stopped had he done this, far back of where the collision occurred, is proved beyond question by the fact that the brakes went on with such force as to break the train in two.

Nevertheless the lesson of the disaster that great care should be exercised in keeping in good order the air brakes on locomotives, especially those in fast passenger service, and in seeing to it that every wheel on the locomotive has its full braking power exerted is one that deserves emphasis. It is well known that locomotive brake equipment requires more attention to keep it in order than the brakes on car equipment. But such attention is too important to safe operation to be in any way neglected.

A feature of Dougherty's testimony which has made a great impression upon the general public is his statement that he attempted to reverse the engine previous to the collision but had not sufficient strength to do so because of having strained his back in handling the reverse lever a week previous. It would be well if this public testimony should lead to the general use of a power reverse gear on modern locomotives. Such gear is already considerably used on some especially heavy types of engines and its use ought to be universal, as has heretofore been pointed out in these columns. In fact the failure to apply power to the reversing gear of heavy locomotives is an example of the lethargy that has prevailed far too largely in steam-locomotive design and construction in this country and which has made our American locomotive-engineering practice lag very far behind that of the more progressive European locomotive designers and builders.

It should be said, however, that use of the reverse lever to stop a train is only justifiable as a last resort. If the air brakes on Dougherty's locomotive in the Stamford wreck were not holding properly after the emergency brake went on, throwing over the reverse lever and opening the throttle might have helped to check the speed. If the locomotive driver brakes *were* holding, however, reversing the engine would only have made matters worse. In general, the instructions to engine runners properly equipped with driver brakes should be to rely on the brakes for stopping the train and not to use the reverse lever.

LETTERS TO THE EDITOR

Licensing Surveyors in Canada

Sir—In view of the discussions which have taken place recently in your columns concerning the bill before the New York Legislature proposing to license engineers, it may be of interest to some of your readers to know something of the status of engineers in Canada.

A sharp line is drawn here between the Land Surveyor and all who practice other branches of engineering. All over the Dominion, those who wish to survey land in any manner which will affect the title to the lands surveyed, must hold a commission as Land Surveyor. If the survey is of Dominion lands, he must be a Dominion Land Surveyor. If the survey is intended to be of record in a Land Titles Office under provincial jurisdiction, he must hold a commission as Provincial Land Surveyor for the province in question.

In Manitoba, Saskatchewan and Alberta, the Torrens title is universal and to a lesser extent in the eastern provinces. Since in this system the government guarantees the title to be good, it is reasonable to expect the government to regulate the manner of survey and inquire into the character of the surveyor.

To acquire a commission as Dominion Land Surveyor, any person may take a preliminary examination covering Euclid, Algebra, Plane and Spherical Trigonometry, Mensuration, Spelling and Orthography. Graduates from recognized colleges or universities in engineering branches may take a limited examination. These examinations are fair tests, though severe to one not fresh from college.

The ordinary applicant must then serve three years' apprenticeship, and the graduate one year's apprenticeship, concluded by a final examination in the same subjects and in addition Astronomy, the Land Titles Act and Manual of Survey.

Surveyors holding a Dominion Land Surveyor's commission may obtain a provincial commission, at least in the three provinces mentioned, by writing an additional examination on the Land Titles Act of the province.

In addition to these precautions, the provincial governments maintain surveyors and staffs who check all plans of subdivisions, and who require all plans submitted to conform to the law and practice; and a public works' surveyor who passes on the feasibility of streets.

Men who wish to practice other branches of the engineering profession are in no way restricted, although (at least in Alberta and Saskatchewan) plans of water-works and sewerage are referred to the provincial sanitary engineer; irrigation, water-power and water-supply plans must be referred to the Commissioner of Irrigation (Dominion). In most cities, also, a city building inspector passes upon building plans. In this province (Al-

berta) no one may practice as an architect but a member of the Alberta Architects' Association.

This provision is by no means rigidly adhered to, the limitation seeming to prohibit a man calling himself Architect without this qualification. In many cases plans are drawn by builders and others who style themselves building inspectors. It is interesting to note that the only serious building failure in recent years during a very active period of building in Calgary, was a building in course of erection for which no architect had made plans, the plans having been prepared cheaply by a carpenter who could use a ruling pen.

F. K. BEACH.

222a 8th Ave., W., Calgary, Alberta, Can.

[At least two of the Canadian provinces have laws regulating the practice of civil engineering. They are Manitoba and Quebec. Under these laws no one is entitled to call himself a civil engineer, or to practice civil engineering unless he is a member of the Canadian Society of Civil Engineers. The Manitoba law went into effect in 1896 and the Quebec law in 1899.—ED.]

Cost of Horse-Drawn Vehicles versus Electric Vehicles

Sir—In ENGINEERING NEWS of May 29, 1913, p. 1149, you state in an article covering the spring meeting of the American Society of Mechanical Engineers that, in the paper read on "Cost of Upkeep of Horse-Drawn Vehicles vs. Electric Vehicles," "the figures given by the author charge only 2% interest on the investment in electric trucks and 10% depreciation, while the friendless horse was charged 6% interest and 20% depreciation."

I am inclosing herewith a copy of the paper and beg to invite your attention to p. 580, table No. 1, in which is given the experience of the Naval Gun Factory at Washington. In this table interest on investment is figured at 2%.

On p. 581, table No. 2, is given the experience of a commercial house in Washington, and this firm charged 6% on their horse-drawn equipment for interest, 20% depreciation for the horse and 15% depreciation for the vehicle and harness. The same company, however, charged 6% for their electric vehicles.

On p. 585, table No. 8, is given the cost per year of the horse-drawn vehicle at the Government Printing Office, and if you will examine this table, you will find that the interest on the investment is given as 2%, depreciation of the wagon 10%, depreciation of the horse 20% and of the harness 15%.

On p. 589, table No. 12, giving the cost of operating an electric truck, you will find interest on investment at 2% and depreciation at 10%.

The object of the above figures is to show that where I made comparisons for electric-driven trucks over horse-drawn trucks, I charged the same interest on investment in the figures given by commercial establishments—namely, 6%, and in the figures given for Government Departments I charged 2% interest on investment against both the horse-drawn and the electric-driven. This was done because the Government borrows money at 2% whereas commercial houses have to pay from 5 to 6%.

The statement given in the ENGINEERING NEWS, as mentioned above, is therefore incorrect, and the author of this statement evidently confused the figures given for commercial houses against the figures given for Government Departments.

Referring to the depreciation charges, I think it is a well known fact that a horse is not much good for heavy trucking service after five years of use, and the horse-drawn wagon is not much good after ten years of use, so that the 20% depreciation on the horse, 10% on the wagon and 15% on the harness represent average figures. The depreciation on electrics is, of course, not yet well understood, but there are plenty of electric vehicles in use at the present time which were purchased 10 years ago, or more, so that the 10% depreciation for this class of vehicle is on the safe side.

W. R. METZ.

Superintendent of Buildings, Gov. Printing Office.

Washington, D. C., June 9, 1913.

[Our correspondent seems to have missed the main point of our criticism. If the relative economy of two different machines is to be compared the comparison should be made *on the same basis* for both. The fact that the firm using one machine may have better credit than the firm using the other, so that it could borrow money at a lower rate of interest has nothing to do with the case. Incidentally we very much doubt that the U. S. Government can at the present time borrow money at 2% interest or anything like it.—ED.]

A Concrete Slab under a Railway Track on a Side-Hill Embankment

Sir—Some of your readers may be interested to learn the result of the work done at Oil City, Penn., in placing reinforced-concrete slabs under a street railroad track, located on the edge of a steep slope. This construction was described in the ENGINEERING NEWS, issue of Feb. 6, 1913, p. 242. It was then said that a year or more might elapse before anything would happen which would demonstrate the success or failure of the method, which was largely an experiment. The demonstration came sooner than was expected.

Before the concrete was two months old, an unusual rainfall, almost continuous for about a week, loosened the soil on the slope so that there was a considerable slide, and the structural strength of the slabs, girders and columns was brought into play, probably for the first time. It may be recalled from the former article that the concrete was laid directly on the ground, which being then firm and hard, not only supported the concrete during constructive work but also while it was hardening. The unusually low initial cost of the work was possible on account of this constructive feature.

If the concrete had not been put in just when it was, the slide would have been far more extensive, the trolley road would have been put out of business for perhaps two months, and the cost of restoring the roadbed and putting in a permanent construction would have been far greater than the actual cost of the work as done last fall. The preliminary estimate for the cost of a stone (or concrete) retaining wall, with the costly system of sheet piling which would have been necessary, was between $4000 and $5000. The preliminary estimate for

the concrete-slab construction was $1150. The actual cost was about $980.

The complete success of the method and its comparatively insignificant cost have induced the management to put in similar construction in two other places where incipient failure of the slope has already begun.

WALTER LORING WEBB,

Harrison Bldg., Philadelphia, Penn.

June 4, 1913.

The Fulfillment of a Prophecy

Sir—In ENGINEERING NEWS of Dec. 19, 1912, p. 1156, you published a communication from me relative to the possible instability of a concrete bridge then nearing completion in an Indiana city. The bridge consisted of two arch spans of 87 and 107 ft. each, supported upon old stone abutments and pier of a former wooden bridge.

It seemed an extremely doubtful matter as to whether or not the structure could remain standing when centers were struck and earth fill added. It is only fair to state that it did remain standing and with no apparent evidence of weakness, although a theoretical analysis showed the design to be extremely dangerous. But it was never subjected to any severe loading test.

RUINS OF A CONCRETE BRIDGE WRECKED BY FLOOD, BROOKVILLE, IND.

(Details of design appeared in "Engineering News," Dec. 19, 1912, p. 1156.)

On Mar. 25, 1913, however, the Easter flood accomplished its destruction. Whether or not the piers or abutments were undermined cannot be definitely determined. A view of the collapsed bridge is shown herewith. It is located in Brookville, Indiana.

DANIEL B. LUTEN.

Indianapolis, May 31, 1913.

Use of Wood Poles in the United States in 1911, by steam and electric railroads, electric-light and power companies, telegraph and telephone companies, are presented for the coming bulletin of the U. S. Census Bureau. The total purchase amounted to 3,418,000, of which 70.3% were purchased by the telephone and telegraph companies, 23% by electric railroads and electric-light and power companies, and 6.7% by steam roads. The total number shows a decrease of 452,700, compared with 1910, and 320,700 compared with 1909, but it exceeds the totals for 1908 and 1907 by 168,900 and 134,800, respectively. The decrease was confined to telegraph and telephone companies and steam railroads. Over 90% were of cedar, chestnut, oak, pine and cypress, standing in that order of relative importance.

Annual Convention of the American Railway Master Mechanics Association

The 46th annual convention was held at Atlantic City, N. J., June 11 to 13, with the usual large and enthusiastic attendance. The meetings were held in the assembly room on Young's Pier, and the exhibits (occupying more space than ever) were arranged upon this pier, except that some cars and other large exhibits were placed upon a railway siding. The program was arranged upon a definite schedule, allowing a specified time to each subject. But the proceedings ran behind the schedule from the very start. However, on the third day, the meeting made good time, and cleared off the entire program without undue haste, and would have finished on time but for the delay incident to balloting for officers.

There was only one session each day (9:30 to 1:30), but in future it may be necessary to have at least one afternoon or evening session to enable the various matters to be given proper consideration. With a three-day convention it should be an easy matter to arrange four or five sessions, and still have plenty of time for the exhibits and the social features of the convention.

The meeting on June 11 was opened with prayer by Rev. N. W. Caldwell. The annual address was then read by the President, D. F. Crawford (Pennsylvania Lines). The report of the Secretary, Jos. W. Taylor, showed a membership of 1074, and that of the Treasurer, Angus Sinclair, showed a bank balance of $1369. The secretary reported also that the endowment fund for four scholarships at the Stevens Institute of Technology is insufficient, and that a committee has been appointed to consider means for maintaining the scholarships. It has been the custom to elect members of long standing to the position of honorary member, but it is felt that this rather detracts from the real purpose of this grade of membership. The Executive Committee therefore proposes a change in the constitution, creating the additional grade of life member. To this may be elected members of 10 years standing who, through age or other cause, may cease to be engaged in railway service.

PRESIDENT'S ADDRESS

The address by Mr. Crawford was far from being of a formal or perfunctory character, but touched briefly and interestingly upon a number of points of particular interest to the railways at this time. In the first place there is much proposed legislation which will affect the railways and which relates to such diverse matters as wages, train crews, headlights, freight rates, safety appliances, and regulations in regard to operation. As the various laws are proposed by the Federal and different State governments there is likely to result a rather chaotic condition of railway regulation, unless something can be done to promote some degree of uniformity.

Smoke prevention is another important matter, and the successful handling of this may do much to check the growing demand for electrification of terminal lines. In view of the increasing immigration and the capacity of many of the foreigners for becoming good workmen in railway service, he suggested the desirability of railway officers studying foreign languages so that they can handle these men without the aid of interpreters. Three

particular subjects were suggested by Mr. Crawford as desirable for investigation by the Association, with a view of effecting uniformity: (1) Train resistance; (2) tonnage rating; (3) statistics of operating costs. As to the first, he showed that in 1900 ENGINEERING NEWS published a chart of 21 diverse formulas, since which time the number has increased materially, with the result of confusing the situation still more. A resolution was passed later recommending that the association take up the investigation of train resistance and train tonnage.

He pointed out also that this year there is no report on the long proposed consolidation of the Master Mechanics and Master Car Builders associations, and it is apparent after several years' consideration that the majority of the members are opposed to this suggestion. Nevertheless, a closer working arrangement is desirable, which may be brought about by holding the conventions of the two associations during one week, and with a joint session on one day. It is desirable also that the Master Mechanics Association should keep in closer touch with the work of the Air Brake, the Railway Fuel and the Testing Materials associations. He expressed the opinion also that the Master Mechanics Association should give more attention to the larger problems affecting railway equipment and operation.

MECHANICAL STOKERS

The report of the Committee on Mechanical Stokers showed very clearly that the practical and economic advantages of such a device have become generally recognized, and that the stoker has reached the commercial stage of development. In fact the report dealt entirely with this side of the question, and did not discuss matters of design or construction, except to state that the stokers are of two classes: The "scattering" (which in a measure imitates the action of hand firing) and the "underfeed." Several makes of stokers were mentioned, most of which have gone out of use, but two are in use in large and increasing numbers: (1) The Crawford "underfeed" stoker, of which 159 are in service and 140 ordered, or 299 in all; (2) the Street "scattering" stoker, with 189 in service and 173 ordered, or 362 in all. The Crawford Stokers are all (except two) on the Pennsylvania System, while the Street stoker is in use on a number of roads.

As to efficiency, the average mileage per stoker failure has been 11,679 miles on the Norfolk & Western R.R. and 4474 miles on the Chesapeake & Ohio R.R. There is still some uncertainty as to a saving in fuel, but a saving of 5% is considered logical from the fact that there is a better fire, the door is kept closed, and the combustion is more complete. There is another possibility of economy in the fact that coals of lower heat value (and lower price) can be used to advantage with mechanical stokers. In starting, steam can be raised quickly and probably with advantage as compared with hand firing, while at terminals the fire can be cleaned or knocked out in much less time than on a hand-fired engine. It is general experience that stoker-fired engines can haul heavier train loads than those fired by hand, and as the former can fire a larger amount of fuel and still retain uniformity in the firing, a higher boiler power is reasonably sure. It must be borne in mind, however, that intelligent care is required to insure efficient operation of the stoker and that the device must constitute an item for locomotive repairs.

The discussion related mainly to the efficiency of the mechanical stoker as proved by actual service experience, and to the advantages which it offers in regard to increased efficiency and economy of railway operation due to the ability to increase train loads. Mr. Crawford stated that it was the desire to increase this load that led the Pennsylvania Lines to take up the matter. The use of the stoker will also permit the use of engines with larger cylinders and greater power than those now in service. A number of engines now being built for the Pennsylvania Lines have cylinders of 2 in. greater diameter than similar hand-fired engines, while some existing engines to which stokers have been applied are having the cylinders bored out to increase the diameter as much as the thickness of the metal will permit. Thus locomotives can be built of greater power than could be operated with hand firing. Mr. Gaines (Cen. R.R. of Georgia) stated that only a few years ago the train tonnage on his road was controlled by the ability of the firemen to deliver coal, but with the introduction of the superheater the fuel economy has been increased to such an extent that the firemen can handle even larger engines than before. He thought there was no doubt of the increased use of stokers on large engines.

Mr. Street (American Stoker Co.) stated that for a comparison of fuel economy it is absolutely necessary to show the coal per mile per hour. He believes that the firemen have come to recognize the mechanical stoker as the "fireman's friend." Mr. Cook (Pennsylvania Lines) has found that at first the performance of stoker engines is good, but then it declines for a while as the men lose interest in the device; but later on, as they get more familiar with its use and its advantages the performance improves materially. Mr. Sinclair pointed out that the stoker will not do its work alone; it needs to be handled carefully and by an intelligent fireman if the best results are to be obtained. An engineer representing the Roumanian Government Railways said that efficiency with hand firing on large locomotives requires good coal and good firemen. As neither of these are available in his country the mechanical stoker is being introduced and promises to give very satisfactory results. We may call attention to the fact that while Mr. Crawford referred to the use of larger cylinders on mechanically fired locomotives, Prof. Benjamin referred to a similar possibility on superheater engines.

LOCOMOTIVES WITH SUPERHEATERS

The committee on this subject made a very brief report of progress, although when continued in 1912 it expected to make a full report on the comparative economy and maintenance cost of locomotives using superheated steam and saturated steam. The increase (if any) in maintenance cost is thought to be negligible. The number of superheater locomotives in the United States and Canada is now 8822, an increase of over 100% since the time of the committee's former report. The engines have been uniformly satisfactory. Troubles with packing and valves, due to the high temperature of the steam, have not developed seriously, and have been overcome by the use of good material in the parts concerned. The cylinders, cylinder bushing, valves and valve bushings must be of a close-grained iron rather harder than is required

when using saturated steam, and the iron should be low in phosphorus and silicon.

The Pennsylvania R.R. is conducting a series of tests of two pairs of engines of the 4:4:2, the 4:6:2 and the 2:8:0 classes, one of each pair using saturated steam and the other having a Schmidt superheater. A voluminous report on these tests of the 4:4:2 engines was presented by Mr. Young (Engineer of Tests, P. R.R.). These showed that an increase of 32% in dynamometer horsepower and 23 to 46% in economy may be expected by the use of superheating. The application of the superheater to a passenger engine will permit an increase of 30% in tonnage rating where starting heavy trains and running at low speeds do not constitute factors in the loading. Where these factors have to be considered, there need be no reduction in the loading of the superheater engine as compared with one using saturated steam.

In close relation to the two reports voted above was a paper read by C. H. Benjamin (Purdue University) on "Tests of Superheater Locomotives." This related to a continuation of tests reported upon in 1911, using the same locomotive but now equipped with a superheater. The important feature of these tests was in regard to the increase in power due to the superheater when the engine is burning the same amount of coal as when it operated on saturated steam. The tests indicated the following: (1) the increase in power due to superheating when burning the same amount of coal (110 to 130 lb. per sq. ft. of grate per hour) varies from 22.6 to 13.0%; (2) for any steam pressure, the percentage of increase in power decreases as the coal consumption increases; (3) for any coal consumption, the increase in power increases as the pressure increases.

Another point was in regard to cylinder diameter. With a coal consumption of 120 lb. per sq.ft. of grate per hour, the increase in power with superheated steam is about 20%. But if the cylinder diameter were made 18¾ in. instead of 16 in. (as with saturated steam) the cutoff with superheated steam could be at a more efficient point, and the increase in power would be raised to about 25% (at 160 to 200 lb. pressure).

In the discussion, Mr. Young (Pennsylvania R.R.) pointed out that very similar results have been arrived at in the Purdue and Pennsylvania tests, carried out independently. He suggested also that conclusions as to increase in cylinder volume should be based on tests with a higher range of speeds than those of the Purdue engine. To increase the volume in large cylinders of maximum available diameter, the stroke may be lengthened slightly, but this must be considered very carefully in relation to possible slipping of wheels with the cylinders of increased stroke. Prof. Benjamin suggested that somewhat similar results in efficiency may be attained by reducing the pressure slightly instead of increasing the cylinder volume.

Firebox Repairs and Boiler Washing

The report of the Committee on Design, Construction and Inspection of Locomotive Boilers related largely to the use of oxyacetylene and electric welding in firebox repair work. It is becoming general practice to weld tubes to the firebox tube sheet, and it is probable that under this method the tubes can be run without removal for more than three years, which is the limit imposed by the new government regulations. For tube welding, the electric process is considered the better and cheaper. Other repairs include the welding of cracks in plates and mud-rings, and the welding of patches in plates. The committee pointed out that each process has a field of its own. It recommended the use of electric welders for roundhouse repairs, while both electric and oxyacetylene welders can be used at the shops, as the latter may be kept busy cutting out and applying new plates.

The committee recommended the washing out of boilers with hot water, and discussed the boiler water conditions as related to water softening, boiler compounds and blowoff cocks. As to flexible staybolts, these are used generally in certain locations only, but some roads are using them throughout the entire firebox, and the committee recommended further experiments in this direction. It suggested also that there should be some slack in these bolts, as if all are screwed tight there will be excessive internal stresses in the firebox. In the discussion, Mr. Pratt (Chicago & Northwestern Ry.) stated that if flexible staybolts are used throughout, there must be some method for taking up slack in the front crown bolts, and this is provided in some special forms of flexible bolts.

The discussion related largely to the use of welders in repair work, indicating that this is a very general and increasing practice, and that as a rule the results are satisfactory. It was generally admitted also that each of the two types mentioned has its particular field of application. Specially satisfactory results have attended the welding of tubes to the tube plate (firebox plate only), and in many cases tube troubles have been eliminated in this way. Mr. Pratt (C. & N. W. Ry.) referred to the government regulation noted above, and to the desirability of getting longer service than three years out of the large superheater tubes when welded into place. He suggested that the purpose of the law is to insure thorough internal inspection of the boiler, and as inspectors admit that the large tubes do not interfere with this, it may be possible to arrange to continue these tubes in service for more than three years.

The old question of the pitting of tubes came up. Mr. Gaines thought this due to the use of steel tubes. He has had this trouble, but eliminated it by abandoning steel tubes. Mr. Bentley, however, has this trouble with both steel and iron tubes on the Chicago & Northwestern Ry.

Three-Cylinder Locomotives

This paper by J. Snowden Bell gave a review of American and foreign three-cylinder simple and compound locomotives, but related especially to simple engines, in which the balancing and the more uniform distribution of the power are characteristic features. The three-cylinder simple locomotive dates back to 1846, when a design was patented by Robert Stephenson and William Howe, but the first locomotives of this type actually built were American engines, built at the shops of the Philadelphia, Wilmington & Baltimore R.R. in 1847. In 1880, and again in 1892 and 1894, some three-cylinder engines for the Erie & Wyoming Valley R.R. were built to the designs of John B. Smith. In 1909, a three-cylinder engine of the 4:4:2 class was built at the shops of the Philadelphia & Reading R.R., to the designs of H. D. Taylor, then Superintendent of Motive Power. Two similar engines and a 4:6:0 engine of the same type were built in 1911 and 1912. No details of performance of these mod-

ern engines were given in the paper, as the railway does not wish to make this information public until there has been greater experience with the engines.

It may be noted that several railways in England and on the Continent are using three-cylinder simple engines (while some also have four-cylinder simple engines). Mr. Bell pointed out that the most important advantage is the substantially uniform turning moment. This gives more rapid acceleration in starting, increased steadiness in running, and reduced destructive action on rails and bridges, together with greater tractive power and utilization of a lower factor of adhesion than a two-cylinder engine. While this involves the use of a crank axle, there is now little objection to such an axle, and in any case an axle with a single crank should be less objectionable than the double-crank axles used on four-cylinder locomotives.

Smoke Prevention

The prevention of smoke from locomotives in and near cities is becoming a more insistent problem for the railways, both in regard to the smoke itself as a nuisance and in regard to the present or prospective relation of this nuisance to the question of electrification. The report, however, did not discuss the problem, but referred to two methods of abating or reducing the smoke nuisance. The first of these is the washing of smoke at roundhouses, and it was stated that several railways are experimenting with a device for this purpose. Presumably this is the device used at the Chicago roundhouse of the Lake Shore & Michigan Southern Ry., which was described and illustrated recently in Engineering News.

The second method is the use of steam jets in the firebox. This has been the subject of extended tests made at the Altoona testing-plant of the Pennsylvania R.R. for a committee of the General Managers Association of Chicago, working in conjunction with the smoke-abatement committee of the Chicago Association of Commerce.

The results of the tests indicate two things: (1) if 4 to 6 lb. of air per lb. of coal fired is delivered over the fire by steam-jet tubes the emission of smoke will be reduced to a very small amount; (2) while the brick arch is a benefit, particularly while the engine is running, the steam-jet combustion tube is of value either with or without the brick arch. The injection of steam and air in combination is more effective than steam or air alone. This method is believed to result in actual economy in fuel consumption, especially in the conditions under which switching engines are operated. The jet tubes should be at least 2 in. diameter, placed in the back or side plates of the firebox and with a $\frac{3}{16}$-in. steam nozzle in each tube. A brief review of the history of this device shows that it was applied as early as 1838. It has been used at various times and has formed the basis of some patented devices for improving combustion.

In the discussion, Mr. Sinclair referred to the early use of steam jets in Great Britain, and to the extremely wasteful methods of firing employed on and permitted by American railways for many years. In fact, one of the troubles at the present time is that the railway officers do not enforce the rules against firing with excessive smoke. As to the steam jet, it is one of the most efficient and economical of smoke-reduction or complete-combustion appliances, and is the basis of numerous patented devices. But to be successful it must be kept in proper condition and handled by a careful fireman. One member stated that several railways at Chicago have equipped a number of locomotives with steam jets, following the lines suggested by the above report on the Pennsylvania R.R. tests, and have had excellent results.

Locomotive Headlights

This subject gave rise to the most animated and protracted discussion of the entire convention. The very brief report of the Committee on Minimum Requirements for Headlights, stated that the functions of a headlight are as follows: (1) to warn employees and the public of the approach of a train; (2) to designate the head of a train; (3) to permit the enginemen to observe wayside objects, such as whistle posts, etc. These requirements can be met by an oil headlight, or a light of the same power as the present oil lamp. The committee proposed a series of tests so that a conclusive report may be made next year. As to high-power headlights, the committee stated that tests confirm the conclusion that they are a decided source of danger on roads with multiple tracks and automatic signals.

Mr. MacBain (Lake Shore & Michigan Southern Ry.) urged very strongly that the convention should take action and state what is the minimum requirement, as such action could be presented to legislative bodies now considering the headlight question. Other speakers thought it might safely be left for a year, so as not to take hasty action, but suggested that the committee should hasten its work and report by next January. Mr. MacBain referred to the Ohio law which provides that the light must enable objects to be seen at a distance of 450 ft. He stated that a 16-in. reflector 9 in. deep with a 25 cp. oil lamp will enable objects to be seen at 350 ft. Legislators are apt to claim that the light should enable the engineman to see a man on the track at such a distance as to stop the train before reaching him, but Mr. Sinclair pointed out that this is requiring the railway to protect people who are violating the law. One member took the position that as high-power lights are unsafe, the association should determine the maximum power of light which it is safe to put on a locomotive.

Mr. Fowler (Midland Ry. of England) rather derided the American headlight, but this merely indicated his unfamiliarity with conditions in this country. A resolution calling for immediate action was lost, but it was decided that while the committee should proceed with its proposed tests it should arrange to have its report distributed by January, or six months in advance of the next meeting.

Maintenance of Electric Railway Equipment

This paper by C. H. Quereau (New York Central R.R.) was of a rather unusual but specially interesting character in that it sought to remove some of the mystery which, to the steam motive-power man (and many another man) seems to surround electricity and electrical work. He explained simply and briefly the meaning of certain fundamental electrical terms. He showed also that from 75 to 90% of the problems of maintenance of electrical equipment can be worked out successfully by a good mechanic who has very limited electrical knowledge but has had experience in the motive-power department of steam roads. He cited several cases of this kind. Of course, some knowledge of electricity is essential, but

this is of an elementary character and practical rather than theoretical. With these conditions understood, men in the mechanical department will have less fear of losing their positions as a result of the increase in electric traction on steam roads.

An electric locomotive is more complicated than the steam locomotive, in number of adjustable or working parts, but the parts are lighter and more easily handled and owing to the ease of replacing parts the engine never needs to go to the shop for a general overhauling. It may readily be seen that there is no particular mystery or danger in the electric locomotive when the records for 1912 (after five years' service) show a cost of less than 4c. per mile and an average of 48,271 miles per train detention due to electrical apparatus, and a record of 249,423 miles without such a detention. We shall print an abstract of this paper later, as of interest to both the old and the young engineer who is not familiar with electrical work, and is apt to regard it with some distrust.

In the discussion, Mr. Keiser stated that on the New York electrified division of the Pennsylvania R.R. the maintenance of locomotives and multiple-unit cars is under a "steam" foreman of 20 years' experience in roundhouse and shop practice. Further, the enginemen on these locomotives become sufficiently familiar with the equuipment in six months' experience to be able to make light repairs on the road. Mr. Bickford (New York Central) said that enginemen find little trouble in learning how to run electric locomotives. But as each type of locomotive has its peculiar features and certain weak points, it is desirable that the men should be particularly familiar with the type of apparatus or the engines they are running, so as to avoid trouble in the handling of high-speed traffic. Mr. Wildin explained that the New York, New Haven & Hartford R.R. has two electric branches which form parts of steam-operated divisions and are under the care of the regular master mechanics. The electrified division at New York has been until recently in charge of an electrical official, but now it is under an assistant mechanical superintendent trained on steam lines, while all the repair work which corresponds to roundhouse work is under a master mechanic of steam experience.

Miscellaneous

Cast-Steel Frames—The Committee on Cast-Steel Locomotive Frames submitted a revised form of the present specifications, which was adopted as "recommended practice," without discussion. While steel with 0.25 to 0.28% carbon is still used, experience indicates that steel of 0.37 to 0.40% carbon is better, and the new specifications require that high-carbon steel frames shall have not less than 0.37% carbon and a reduction in area of not less than 25%. The tensile strength of the material is specified as 70,000 lb., while the old specifications called for not less than 55,000 lb. and in many existing specifications the range is from 60,000 to 80,000 lb. Although vanadium steel is extensively used for frames, the committee did not consider it advisable to submit standard specifications for this class of steel.

Main and Side Rods—The Committee on Main and Side Rods presented its specifications as previously submitted in 1911, and these were adopted as recommended practice. Mr. Gaines (Cen. R.R. of Ga.) referred to the general impression that in American practice the rods are very much heavier than in English practice, even for engines of approximately similar power, but he thought that in engines of comparable dimensions there is not now very much difference. Mr. Fowler (Midland Ry., England) considered that American rods are much the heavier, even for approximately similar engines, but he stated that in English practice the rods are given a special heat treatment to improve the quality of the steel.

Tires and Wheels—The Committee on Steel Tires re-submitted its specifications as presented last year, and these will now go to letter ballot. There was no discussion, but a recommendation to make this a standing committee was referred to the executive committee. The The Committee on Engine and Tender Wheels submitted specifications and gages for steel wheels, and recommended the adoption of the M. C. B. specifications for cast-iron wheels as adopted in 1912. It has done nothing to prepare designs for cast-iron wheels for tenders of 70 tons capacity, as no action has been taken as yet upon the question of increased thickness of flange and its relation to frog and guard-rail clearance. The committee's recommendations will be submitted to letter ballot.

Boiler Tubes—The Committee on Specifications for Materials submitted specifications for steel boiler tubes, agreeing closely with those of the American Society for Testing Materials. The carbon content, however, is given as 0.08 to 0.18% (instead of being "not over 0.15%") and large superheater and arch tubes are included as well as 2½-in. boiler tubes. The hydraulic pressure test is specified as 1000 lb. for the latter, and 800 lb. for tubes of 5 in. diameter and over. These specifications will go to letter ballot.

Special Grades of Steel—The Committee on Alloy Steels and Heat-Treated Steel presented an interesting report showing the varied and increasing use of such special grades of steel. We shall give an abstract of this later. The discussion showed, however, that there has been some considerable trouble due to defective metal. Mr. Young, Engineer of Tests of the Pennsylvania R.R., stated that close inspection and test is essential to securing good material. Otherwise, the heat-treated steel may be inferior to the carbon steel. Further, the heat treatment will make poor steel worse, but will improve good steel.

Standards—The Committee on Revision of Standards suggested a number of minor changes, but showed that a comparatively few members take enough interest to consider the standards or even to vote upon them when submitted to letter ballot. The committee suggested that a larger vote be required for the adoption of standards, and a resolution was passed that no standard would be adopted until it has been listed as a "recommended practice" for at least a year. The only other discussion was on the committee's suggestion that the present specifications for wrought-iron axles should be eliminated, since such axles are undesirable. The committee's recommendations will be submitted to letter ballot.

Officers

The election of officers resulted as follows: President, D. R. MacBain, Superintendent of Motive Power, Lake Shore & Michigan Southern Ry., Cleveland, Ohio; Vice-

Presidents, F. F. Gaines (Central R.R. of Georgia), E. W. Pratt (Chicago & Northwestern Ry.), and Wm. Schlafge (Erie R.R.); Treasurer, Angus Sinclair, New York. The Secretary is Joseph W. Taylor, of Chicago.

The Tunnel Accident at Fifty-sixth St. and Lexington Ave. New York City

The cave-in of three to four hundred tons of rock, which took place in the subway excavation at Fifty-sixth St. and Lexington Ave., at 6:10 p.m. on June 14, was caused by seams in the solid rock. Two of these seams running diagonally on each side and above the roof of the express tunnel, met at about 11 ft. above this roof, extending longitudinally on both sides about 30 ft., and forming what is commonly known as a bell. The seams parted, either as the result of a blast or from the dead weight of the rock, and the cohesion between them was insufficient to bear the mass which slid and fell into the excavation for the express tunnel. Ten workmen were killed and three injured.

The rock which fell formed the roof of what was destined to be the express tunnel, being situated beneath the tracks for the local tunnel. From the cave-in, the excavation extended about 70 ft. north and 140 ft. south.

The shoring was of the heaviest timber used for such a purpose, all being of 12x12-in. yellow pine. Longitudinal beams, or wallplates, rested on either a rock shelf or upon posts. From these wallplates, arch beams were placed every 4 ft., thus allowing only 3 ft. of rock between the beams.

The mass broke into large pieces, the maximum being about 15 ft. square and 8 ft. thick. In falling it carried away about 8 cross timbers. The wallplates remained in position.

At the informal hearing before Public Service Commissioners McCall and George V. S. Williams, on June 16, at 3 p.m., Mr. Alfred Craven, Chief Engineer of the Commission, Mr. Robert Ridgway, Engineer of Subway Construction, Public Service Commission and Mr. Bayly Hipkins, Chief Engineer of the Bradley Contracting Co., which is doing the work of subway excavation, all stated that the shoring was of sufficient strength to carry any normal load; and that no timber would have sufficed under such excessive load conditions. The danger could not be foreseen for the rock formation, Manhattan schist, was good. The rock within the confines of the seams was of too great bulk to give forth any false vibrations from the usual method of sounding. The accident is, apparently, one of the dangers always present in tunneling work which it is impossible wholly to guard against.

Flood Protection Measures are now being considered by several of the large cities which suffered from the unprecedented floods a few weeks ago. The city of Columbus, Ohio, has appointed John W. Alvord, of Chicago, as consulting engineer to prepare plans and report on flood protection. The city of Dayton, Ohio, has appointed a board of consulting engineers to consider the Miami Valley drainage and the flood protection of the city. This board is composed of John W. Alvord, of Chicago, Daniel W. Mead, of Madison, Wis., and S. M. Woodward, Professor of Hydraulics at The University of Iowa. The board will consider alternative plans for the Miami Valley Work which have been prepared by Mr. Morgan, of Dayton.

Steam Jets for Smokeless Combustion on Locomotives*

These tests were made to determine the merits and proper application of steam-jet combustion tubes in a locomotive firebox for abating smoke, both with and without a brick arch, the special purpose being the development of a specification applicable to locomotives operating in Chicago.

In brief, the results show that if from 4 to 6 lb. of air per pound of coal fired is delivered over the fire by steam-jet tubes, the emission of smoke will be reduced to a very low amount, and that while the brick arch is a benefit (particularly while the locomotive is running), the steam-jet combustion tube is of value either with or without a brick arch.

The locomotive was equipped with a brick arch consisting of six rows of bricks supported on two 3-in. tubes, with a 5-in. gap between the flue sheet and the front of the arch.

There were eight steam-jet combustion tubes along each side of the firebox, six above the fire door on the back head, and four below the fire door. The tubes consisted of pieces of 2-in. boiler tube, approximately 6 in. long, inserted in place of stay-bolts. Each tube was provided with a $\frac{5}{16}$-in. steam nozzle connected to a $\frac{1}{2}$-in. steam line. Separate valves controlled the steam admission to each set of tubes.

CONCLUSIONS

SMOKE—The steam-jet combustion tube has a decided value in reducing smoke under the widely varied conditions of these tests. The air injected by the tube was found to be the greatest factor in reducing smoke, although a small amount of steam seems essential in smoke reduction.

When using steam jets, injecting air into the firebox, it was apparent that a greater reduction in smoke was accomplished by their use with improper firing as compared with careful firing.

The firebox temperature was found to be higher when the arch was in service as compared with the plain firebox, although the data do not consistently show that a reduction in smoke follows increased firebox temperature.

The brick arch showed a considerable reduction of smoke when running, due presumably to higher firebox temperatures, and better mixing of the gases of combustion. In the standing tests, the brick arch showed little, if any, benefit in the way of smoke reduction when the proper mixture of air and steam is supplied.

The steam-jet tubes seem to give the best results in preventing smoke when located so that the injected air and steam meet the flame as high as possible above the fuel bed. If the arch is used, the best results seem to be obtained when the air passes underneath the arch as high as possible above the fuel bed.

The arch gives better results in smoke prevention if it fits tight against the flue sheet. A tight arch, however, has the practical disadvantage of collecting deposits of sparks and eventually closing the lower flues.†

An efficient design of smoke-box blower is an important factor in smoke abatement. Air openings in the fire door are of slight assistance, as they are capable of supplying only about 10% of the air necessary above the fire and a very small percentage of the total air for complete combustion.

The best results were obtained when from 4 to 6 lb. of air per pound of coal fired was injected by the steam tubes from the back head above the fire door. The total amount of air, including that which was introduced above the fire, should be not less than 13 lb. per pound of coal for good smoke prevention.

The tests indicate that the best results can be obtained when the least amount of steam is injected with the greatest amount of air.

ECONOMY—The use of the steam-jet tubes results in considerable economy, and in the efficiency tests an increase in evaporation was obtained.

SPARKS—The steam-jet tubes apparently reduce the weight of sparks discharged from the stack, but the data were not of a character to firmly establish this point.

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*From a report of tests made by the Pennsylvania R.R. at Altoona for a committee of the Railway General Managers Association of Chicago, which is working in conjunction with the smoke abatement committee of the Chicago Association of Commerce. This report was submitted at the annual convention of the Railway Master Mechanics Association by the Committee on Smoke Prevention.

†As to this, one speaker in the discussion, stated that he puts a spark hopper between the brick arch and the tube plate. In this way he gets the advantage of a tight arch and avoids trouble from the accumulation of sparks and dirt against the tubes.—Ed.

BLOWER VALVE—There is a necessity for a quick-acting, easily operated valve capable of giving reasonable graduations in pressure.

STEAM NOZZLES—It was found that the steam nozzles were being worn by the steam and this accounts for the inability of the steam lines to supply as great a pressure to the jets as desired in some of the later tests. The nozzles were made of brass. They should be made of steel and, if necessary, hardened.

The $\frac{3}{16}$-in. steam nozzle seems to be the desirable size to use in a 2-in. tube.

There is noise incident to the use of the steam-jet tubes in the most efficient arrangement. If the tubes are located in the cab, they should be covered with a cast-iron box provided with a cast-iron air intake from a point outside the cab, the air intake being provided with a muffler.

NOTES FROM THE ENGINEERING SCHOOLS

MICHIGAN COLLEGE OF MINES—A series of extension lectures through the larger towns of the lower Michigan peninsula has been undertaken. The lectures will be given by Prof. E. D. Grant and the subject will be "Copper Mining in Michigan." They will be illustrated by lantern slides and by specimens of copper-bearing minerals.

CARNEGIE INSTITUTE OF TECHNOLOGY—A pamphlet has been published by the Institute, entitled "Suggestions Concerning the Choice of a Course in Engineering." The pamphlet is intended to give the students in the preparatory classes some elementary knowledge of what the work of an engineer is and what classes of work engineers taking up different specialties will be called upon to perform. Following the introductory pages, devoted to an explanation as to what in general the work of the engineer consists of, a separate section is devoted to each of the special courses, such as chemical engineering, civil engineering, commercial engineering, mechanical engineering, etc.

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A Broken Axle on a Big Four freight train, near Stockwell, Ind., on June 1, caused the demolition of twelve cars. Two tramps were killed and five more injured.

A Boiler Explosion on the steam barge "E. M. Peck," of Duluth, on June 11, in Racine harbor, caused the death of four men, the injury of two, while two others are missing.

An Unseaworthy Ferryboat, crossing the river Tcheptsa, in Russia, toward the town of Glazov sank on June 5. Fifty persons were drowned.

Five Tons of Fireworks Exploded on June 11, in a flour mill at Deerfield, Mass. The damage, due to the wrecked buildings in the vicinity, is estimated at $40,000, according to press dispatches.

The Destruction, by Fire, of the Groveland Bridge, which carries the only trolley line from Haverhill to Groveland and West Newbury, Mass., on June 3, caused the cutting off of communication between the latter towns and Haverhill. The fire was presumably caused by the electric wires on the bridge, which was an old structure.

A Broken Truck on the Tender of the leading engine of a freight train on the Clinchfield Division of the Norfolk & Western R.R., near Cleveland, Ohio, on June 8, caused the two locomotives which were drawing the train to plunge down a steep embankment. The leading engine crashed into a house, situated at the foot. Its two occupants were scalded to death by the escaping steam from the locomotive. The engineer and the fireman of this locomotive were killed.

A Big Four Engine Sideswiped Two Box Cars in the railroad yards near Norwood, Ind., on June 6. The engineer was killed by escaping steam from broken steam pipes. The General Manager of the Big Four lines stated that the accident resulted from the yard switching crew backing a string of box cars onto a siding too short to contain all the cars.

The New York State Hydro-Electric System, which was proposed in connection with a plant at Vischer's Ferry on the Mohawk River, near Albany, has been temporarily killed off by Governor Sulzer's veto of a bill appropriating $600,000 for commencing the work. The veto was not made on the grounds that a state hydro-electric system was inadvisable, but that the bill was defective and the project to develop power at this point was open to criticism. The governor's memorandum shows that, in his opinion, a better situation would be at Long Sault, on the St. Lawrence River, where a much greater amount of power can be developed and where the river shows greater uniformity of flow throughout the year. He proposes also, to appoint a commission of experts and disinterested citizens to investigate the Vischer's Ferry, Long Sault, Niagara, Genesee, and other possible water-power developments to determine what course is best for the state. He expects to have the report ready for the consideration of the next legislature.

A New Water-Supply for Winnipeg, Manitoba, from Shoal Lake, the western part of the Lake of the Woods, is to be reported on by Rudolph Hering and James S. Fuertes, of New York City, and F. P. Stearns, of Boston, who have already spent some time on the ground. In 1897, when the population of Winnipeg was 40,000, Mr. Hering recommended a ground water-supply for the city, which has been developed to a capacity of some 9,000,000 Imp. gal. per day and is now being extended to 20,000,000 Imp. gal. capacity. This water has the great hardness of 150 to 170 parts per million of temporary hardness and double that amount of permanent hardness. In 1907, the city appointed a board of consulting engineers to report on a larger and softer supply. The board, which consisted of James H. Fuertes, R. S. Lea, J. E. Schwitzer and Geo. C. Whipple, recommended a filtered supply from the Winnipeg River, but no action to that end has ever been taken. The population of Winnipeg is now estimated to be some 200,000, or five times what it was fifteen years ago.

Increased Activity in Shipbuilding—Returns received by the Bureau of Navigation of the Department of Commerce indicate that the current fiscal year will show an output of American shipyards greater than for any of the past four years, and equal to the average annual output for any series of active years of construction. For the nine months ended Mar. 31 the merchant vessels built in the United States and officially numbered by the Department comprised 1114 of 260,265 gross tons, compared with 1051 of 151,341 gross tons for the corresponding nine months a year ago. As the spring and early summer are generally the season of greatest progress, the output for the year will probably reach 400,000 tons. Steel steamers built aggregate 151,507 tons, compared with 75,507 tons for the corresponding nine months a year ago. Shipbuilding on the the Great Lakes shows little change, but the total output on the Atlantic seaboard has increased from 64,522 tons to 161,061 tons. Wood sailing vessels show a decrease and form only a small fraction—11,971 tons—of the total for the United States.

The New Test-Weight Car Equipment ordered by the Bureau of Standards, Washington, D. C., for the testing of railroad scales differs radically in principle from any in use. Instead of the wheels, brakes and other movable parts of the car constituting part of the standard weight, as is the usual practice, a series of 10,000-lb. weights and a truck for moving them on the scales, will be carried in a specially designed car provided with a power crane, etc., for handling the weights. This allows the weights to be standardized and transported to any point with a reasonable assurance that they will remain constant. Under the present method, with the running gear included in the weight of the test car, it is necessary to verify this weight at frequent intervals.

The complaints of shippers against the railroads to the effect that the latter are charging excessive weights has been called to the attention of the Bureau, which expects to begin, soon after July 1, an inspection of the railroad scales, starting with those of the Eastern lines. This is a new departure as the railroads have always operated their own scales entirely free from federal inspection.

Lock-Gate Accident on Welland Canal—A rather unusual accident happened on the Welland Canal about 5 o'clock Sunday morning, June 8, when all four gates of Lock 1, at Port Dalhousie, were carried out and traffic through the canal was interrupted for about 36 hours.

The steamer "Lloyd S. Porter," of the Interlake Line, upbound, had just finished laying up two barges and was proceeding to tie up along the east approach wall about 200 yd. below the lock, to await the preparation of the lock to receive her. In the meantime, the steamer "Neepawah," also upbound, was about midway in the level between Locks 1 and 2. The upper gates were still open and the water in the lock at the level of the upper reach. The engineer of the "Porter"

misunderstanding the captain's signal to reverse, gave her speed ahead. When she was about 50 ft. from the lower gates, the engines were finally reversed, too late. She struck the west gate a blow sufficient to unmiter the gates. The lift at this lock is 14 ft. and the rush of water tore the two lower gates from their anchorages and they became firmly wedged, one above the other, between the lock walls. The sudden rush of water from the reach above also carried out the upper gates down through the lock and over the two lower gates into the harbor below. The captain of the "Neepawah," which was approaching Lock 2, became aware of what had happened, and, giving his vessel full speed ahead, succeeded in making Lock 2 before the water had lowered enough to ground his boat or for the current to carry her back toward Lock 1.

The reaches between Locks 1 and 2 of both the old and new canals are connected, and, had it not been for the very large pondage thus afforded, the "Neepawah" would have been unable to get safely in Lock 2 and the accident would have been much more serious.

The pondage above Lock 1 is so great that it took fully 12 hr. for the water above Lock 1 to get down to Lake Ontario level. This also delayed the commencement of making repairs and the resuming of traffic after the repairs had been made.

Four spare gates were put in and navigation resumed about 6 o'clock Monday evening, June 9. The damage is estimated at about $6000. The "Porter" received very small injury, her rudder being slightly damaged.—From information furnished by W. H. Sullivan, Superintending Engineer, Welland Canal, St. Catharines, Ont.

PERSONALS

Mr. J. T. Morrison, formerly Traffic Manager of the Pullman R.R., Chicago, Ill., has been elected Vice-President.

Mr. W. A. Royce, a graduate of the Michigan State College of Mines, has been appointed City Engineer of Traverse City, Mich.

Mr. W. F. Devine, of Erie, Penn., has been appointed Superintendent of Motor Cars, Chicago, Peoria & St. Louis R.R., Springfield, Ill.

Mr. W. S. Hawkins, of Jefferson City, Mo., has been appointed State Highway Engineer of Missouri, at a salary of $2000 per annum.

Mr. W. A. Durham has resigned as Assistant General Manager of the Missouri, Kansas & Texas Ry., St. Louis, Mo., and the office has been abolished.

Mr. Willis E. Morse, General Manager of the Denver, Northwestern & Pacific Ry., has been elected Vice-President and General Manager.

Mr. Theodore G. Sechrest has been appointed General Mechanical Inspector of the Louisville & Nashville R.R., with headquarters at Louisville, Ky.

Mr. Paul Schultze, M. Am. Soc. C. E., formerly City Engineer of Troy, N. Y., has been appointed Deputy Commissioner of Highways of New York State.

Mr. Dan D. Schrenck, Treasurer of the Toledo & Indiana R.R., Toledo, Ohio, has been elected President, succeeding his father, the late S. C. Schrenck.

Mr. F. W. Mellor, formerly of Warren & Wetmore, Architects, New York City, has been appointed Architect of the New York, New Haven & Hartford R.R.

Prof. F. A. Laws, M. Am. Inst. E. E., Associate Professor of Electrical Engineering at the Massachusetts Institute of Technology, has been promoted to be Professor.

Mr. L. E. Moore, Assoc. M. Am. Soc. C. E., has been promoted from Assistant Professor to be Associate Professor of civil engineering at the Massachusetts Institute of Technology.

Mr. Frank B. Barclay, former Master Mechanic of the Illinois Central R.R., at McComb, Miss., has been promoted to be Superintendent of Motive Power of the lines south of the Ohio River.

Mr. R. S. de Mitkiewicz, formerly connected with the truck department of the Peerless Motor Car Co., has joined the staff of the truck department of the American Locomotive Co., New York City.

Mr. Joseph H. Nash, former Superintendent of the Burnside Shops, Illinois Central R.R., Chicago, Ill., has been promoted to be Superintendent of Motive Power of the lines north of the Ohio River.

Mr. George B. Preston, M. Am. Soc. M. E., recently appointed Assistant Professor of steam engineering at Columbia University, retains his connection with Westinghouse, Church, Kerr & Co., until July 1.

Mr. George R. Sinnickson, Assoc. M. Am. Soc. C. E., formerly Division Engineer of the Pennsylvania R.R., at Williamsport, Penn., has been promoted to be Superintendent of the Schuylkill division.

Mr. A. N. Doud has resigned his position with the Acme Equipment & Engineering Co., of Cleveland, Ohio, to enter practice for himself under the firm name of the A. N. Doud Engineering Co., Cleveland.

Mr. J. J. Rhodes, formerly Division Engineer of the Pennsylvania R.R., at Altoora, Penn., has been appointed Superintendent of the Central division of the Philadelphia, Baltimore & Washington R.R.

Mr. G. O. Huckett, former Road Foreman of engines of the Chicago, Burlington & Quincy R.R., at Wymore, Neb., has been promoted to be Master Mechanic at Sterling, Ohio, succeeding Mr. H. M. Barr, resigned.

Dr. D. E. Thomson, President of the Mexican Northern Power Co., and a prominent financier of Toronto, Ont., has been elected President of the Porto Rico Ry., which is controlled by Canadian capitalists.

Mr. C. I. Leiper, formerly Division Engineer of the Philadelphia, Baltimore & Washington R.R., at Jersey City, N. J., has been promoted to be Principal Assistant Engineer with headquarters at Wilmington, Del.

Mr. J. W. Howard, formerly Instructor, has been promoted to be Assistant Professor of topographical engineering at the Massachusetts Institute of Technology. Mr. Howard graduated from the Institute in 1903.

Mr. Samuel Barnes, recently with the Cape Girardeau-Jackson Interurban Ry., Cape Girardeau, Mo., has been appointed Superintendent of the Jersey Central Traction Co., with headquarters at Keyport, N. J.

Mr. Alexander Robertson, former President of the Western Maryland Ry., has been appointed Assistant to the President of the Missouri Pacific Ry. system, with headquarters at St. Louis, Mo., succeeding Mr. Finlay J. Shepard.

Mr. H. L. Watson, Jun. Am. So. M. E., formerly Sales Engineer of the Allis-Chalmers Co., of Milwaukee, Wis., at Boston, Mass., has been appointed Sales Manager of the De Laval Steam Turbine Co., Trenton, N. J.

Mr. G. E. Russell has been promoted from Assistant Professor to be Associate Professor of civil engineering at the Massachusetts Institute of Technology. Prof. Russell graduated from the Institute in the class of 1900.

Mr. R. J. Knight, formerly Assistant Roadmaster of the Colorado & Southern Ry., at Trinidad, Colo., has been appointed Roadmaster of the Northern Pacific Ry., at Staples, Minn., succeeding Mr. Philip McGuire, retired.

Mr. J. M. Scott, former Supervisor of Transportation of the Baltimore & Ohio R.R., and more recently Assistant Superintendent at Keyser, W. Va., has been promoted to be Superintendent of the Monongah division at Grafton, W. Va.

Mr. William Lynch, formerly Trainmaster of the Texas & Pacific Ry., at Bunkie, La., has been promoted to be Superintendent of the Rio Grande division, at Big Spring, Tex., succeeding Mr. A. G. Whittington, resigned, as noted elsewhere.

Mr. G. S. Strout, Asoc. M. Am. Soc. C. E., formerly Assistant Engineer of the State Railroad Commission of California, has been appointed Assistant Engineer for John S. Eastwood, Consulting Hydraulic Engineer, of San Francisco, Calif.

Mr. Newman Erb, of New York City, President of the Ann Arbor R.R., the Minneapolis & St. Louis R.R., the Pere Marquette R.R., and the Tennessee, Alabama & Georgia R.R., has been elected President of the Denver, Northwestern & Pacific Ry.

Mr. A. G. Whittington has resigned as Superintendent of the Rio Grande division of the Texas & Pacific Ry., at Big Spring, Tex., to become Superintendent of the San Antonio division of the International & Great Northern Ry., at San Antonio, Tex.

Prof. George F. Swain, President of the American Society of Civil Engineers, and Professor of Civil Engineering at Harvard University, has been chosen Chairman of the Boston Rapid Transit Commission, of which he has been a member since 1894.

Mr. Alfred E. Roche, Deputy City Engineer of Troy, N. Y., has been promoted to be City Engineer, succeeding Mr. Paul Schultze, M. Am. Soc. C. E., resigned as noted elsewhere. He

is succeeded as Deputy City Engineer by Mr. John C. Watts, at present Assistant City Engineer.

Mr. George C. Koons, formerly Engineer of the Cumberland Valley R.R., at Chambersburg, Penn., has been appointed Assistant Engineer of maintenance-of-way of the Pennsylvania R.R. in charge of bridges and structures, with headquarters at Philadelphia, Penn.

Mr. John Duder, Assoc. M. Am. Soc. C. E., Principal Assistant City Engineer of Salt Lake City, Utah, has resigned to become Chief Engineer for the A. A. Clark Co., Contractors, of Salt Lake City. Mr. Duder has served in the city engineering department for many years.

Mr. Earle B. Phelps, Assoc. Am. Soc. C. E., Consulting Sanitary Engineer, of New York City, and Assistant Professor of research in chemical biology at the Massachusetts Institute of Technology, has been promoted to be Associate Professor of research in chemical biology.

Mr. James Mapes Dodge, Past-President of the American Society of Mechanical Engineers, Chairman of the Board of Directors of the Link-Belt Co., Philadelphia, Penn., was awarded the honorary degree of Doctor of Engineering by Stevens Institute of Technology at the recent commencement.

Mr. Philip Carroll, Assistant General Superintendent of the Southern district of the Missouri Pacific Ry. System, has been appointed Superintendent of the Missouri division, with headquarters at Poplar Bluff, Mo., succeeding Mr. J. Cannon, who has been transferred to the Eastern division at Sedalia, Mo.

Mr. J. H. Kimball, M. Am. Soc. C. E., Designing Engineer for the Commissioners of Sewerage, Louisville, Ky., has resigned to become associated with Stonestreet & Ford, Consulting Engineers, of Louisville, Ky. Mr. Kimball graduated in sanitary engineering at the Massachusetts Institute of Technology in 1894.

Mr. S. G. Porter, M. Am. Soc. C. E., for the past six years Chief Engineer of the Arkansas Valley Sugar Beet & Irrigated Land Co., Holly, Colo., has resigned to accept the position of Inspection Engineer on the staff of the Commissioner of Irrigation, Department of the Interior, Canada, with headquarters at Calgary, Alta.

Prof. Henry M. Howe, M. Am. Inst. M. E., Senior Professor of metallurgy at Columbia University, will retire from active work at the end of the present term, June 30, with the title of Professor Emeritus. Prof. Howe graduated from Harvard University in 1869 and from the Massachusetts Institute of Technology in 1871. He has been Professor of metallurgy at Columbia since 1897.

Mr. A. B. Clark, formerly Principal Assistant Engineer of the Philadelphia, Baltimore & Washington R.R., at Wilmington, Del., has been promoted to be Assistant Engineer of maintenance-of-way of the Pennsylvania R.R. in charge of roadway and track, with headquarters at Philadelphia, Penn. Mr. Clark graduated from Lafayette College in 1891 and entered the service of the Pennsylvania R.R. as a rodman.

Mr. James C. Harding, M. Am. Soc. C. E., has resigned from the firm of George W. Fuller, M. Am. Soc. C. E., Consulting Hydraulic Engineer and Sanitary Expert, New York City, to open an office of his own at 170 Broadway, New York City, for practice in hydraulic and sanitary engineering. Mr. Harding has been a member of the firm of George W. Fuller for the past two years, and has had 21 years' experience in engineering work.

Mr. J. W. Knightlinger, formerly Assistant Superintendent of the Sacramento division of the Southern Pacific Ry., has been appointed Superintendent of Morgan's Louisiana & Texas R.R. & Steamship Co., and the Louisiana & Western R.R., at New Orleans, La. Recently Mr. Knightlinger has been Assistant Superintendent of these lines. He began railway work in 1894 as a messenger with the Chicago, Milwaukee & St. Paul Ry., at Mason City, Iowa.

Mr. Carl F. Pilat, a member of the firm of Hinchman & Pilat, Landscape Architects, New York City, has been appointed Landscape Architect of the Department of Parks of the Boroughs of Manhattan and Richmond, New York City, at a salary of $4000 per annum, succeeding Mr. Charles D. Lay, resigned. Mr. Pilat is a graduate of Cornell University, class of 1900, and has been associated with Mr. Frederick B. Hinchman for the past 13 years.

Mr. J. B. Carothers, recently Special Engineer on the staff of the Chief Engineer of the Baltimore & Ohio R.R., has been appointed Assistant to the General Superintendent, with headquarters at Cincinnati, Ohio. Mr. Carothers has had many years' experience in both the engineering and operating departments. He has been Division Engineer, Division Superintendent, and at one time was Chief Engineer of Maintenance-of-Way of the Baltimore & Ohio Southwestern R.R.

Mr. Edward Chambers, formerly Assistant Freight Traffic Manager of the Atchison, Topeka & Santa Fé Ry., Coast Lines, at San Francisco, Calif., has been elected Vice-President of the Atchison, Topeka & Santa Fé Ry., in charge of traffic, with headquarters at Chicago, Ill. Mr. Chambers began his railway experience as a freight handler at Pueblo, Colo., with the Atchison, Topeka & Santa Fé Ry. in 1878. He has passed through practically every grade in the freight-traffic department.

Col. B. W. Dunn, of New York City, Chief Inspector of the Bureau of Explosives and Combustibles of the American Railway Association, has been elected a member of the council of the Underwriters' Laboratories, Chicago, Ill. The work carried on by Col. Dunn is similar in many respects to that undertaken by some departments of the Underwriters' Laboratories, and the addition of Col. Dunn to the council is expected to aid the establishment of uniformity in fire prevention engineering practice.

Mr. H. E. Stitt, for the past 10 years in blast-furnace work for the Jones & Laughlin Steel Co., the Elyria Iron & Steel Co., and the Carnegie Steel Co., of Pittsburgh, Penn., has been appointed Associate Designing Engineer of the Samuel Austin & Son Co., of Cleveland, Ohio. Recently Mr. Stitt was Resident Engineer and Construction Superintendent for A. G. McKee, M. Am. Soc. M. E., Consulting Engineer, of Cleveland. Mr. Stitt was also Assistant Engineer for the late Anton Burchard, Consulting Engineer of Cleveland.

Mr. Howard C. Phillips, Assoc. M. Am. Soc. C. E., Valuation Engineer of the Atchison, Topeka & Santa Fé Ry. System, Chicago, Ill., has been elected Alumni Trustee of Princeton University. Mr. Phillips graduated from Princeton in 1890 and has been a prominent member of various alumni associations, being at one time President of the Association of Southern California. The Princeton Engineering Association, composed of the graduates from technical courses, has long sought to place an engineering graduate on the Board of Trustees, and the election of Mr. Phillips was accomplished by a large majority of the alumni vote.

Mr. P. H. Morrissey, former Grand Master of the Brotherhood of Railroad Trainmen, has been appointed Assistant to the Vice-President in charge of operation of the Chicago, Burlington & Quincy R.R. Mr. Morrissey was born at Bloomington, Ill., Sept. 11, 1862. He entered the railway service with the Chicago & Alton R.R. in 1879, and served successively as a passenger brakeman, freight brakeman and freight conductor. In 1890 he was elected Vice-Grand Master of the Brotherhood of Railroad Trainmen, and in 1895 Grand Master. In this office he was prominent in the amicable settlement of several labor disputes and served on a number of arbitration boards.

Mr. C. M. Larson, Assoc. M. Am. Soc. C. E., Assistant Chief Engineer of the Wisconsin State Board of Assessment and the Railroad Commission of Wisconsin, has been chosen to succeed Prof. W. D. Pence, M. Am. Soc. C. E., as Chief Engineer. Prof. Pence was recently appointed one of the five engineers in charge of the Interstate Commerce Commission's valuation of the railroads of the United States, as noted in our issue of May 15, 1913. Mr. Larson is a native of Wisconsin and a graduate of the University of Washington. He has been connected with the State Board of Assessment since 1903, with the exception of a year's work in railway construction in Mexico.

Prof. F. O. Marvin, M. Am. Soc. C. E., Dean and Professor of civil engineering at the University of Kansas, has resigned after 38 years association with the University. Prof. Marvin has felt obliged to give up his active duties because of ill health, but in recognition of his long and faithful service the Board of Administration has elected him Advisory Dean, and his connection with the University will not be severed. Prof. Marvin has been Dean of the College of Engineering since 1891. He is succeeded as Dean by Prof. P. F. Walker, M. Am. Soc. M. E., Professor of Mechanical Engineering. Prof. Walker is a graduate of the University of Maine, class of 1896, and of Cornell University.

Mr. Charles B. Buerger, Assoc. M. Am. Soc. C. E., recently Assistant Engineer, Department of Gas, Water Supply and Electricity, City of New York, and for the past two years Senior Assistant Engineer in the filtration division of the department, has joined the firm of George W. Fuller, M. Am. Soc. C. E., Consulting Hydraulic Engineer and Sanitary Expert, New York City. Mr. Buerger entered the service of the Bureau of Filtration, Philadelphia, Penn., in 1906, as a mechanical engineer, and was engaged upon the design, construction and testing of pumping stations and equipment. Later he was engaged on the design of the preliminary filters at Torresdale and Belmont, and of the filter plant at Queen Lane.